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[Compiled from the records of Prof. J. W. Powell, Geologist.]

THE CAÑONS OF THE COLORADO.

A MEMORABLE exploring expedition under direction of the Smithsonian Institution was fitted out by Prof. J. W. Powell, and started in May, 1869, from the station of the Union Pacific Railroad on Green River. The party consisted in all of ten men in four boats, with liberal supplies of provisions, clothing, and ammunition, etc., and sextants, barometers, compasses, thermometers, and other instruments for scientific work. The object of the expedition was to explore a region never before fully traversed by our countrymen, to follow the Colorado through its vast cañons marked by the wreck and death of the few who had dared to enter their mysterious solitudes.

The Colorado River is formed by the junction of the Grand and Green. The Grand River has its source in the Rocky Mountains, near Long's Peak, Colorado. The Green River rises near Fremont's Peak, in the Wind River Mountains, between Idaho and Wyoming. The Green River is larger than the Grand, and is properly a continuation of the Colorado. Including the Green the whole length of the Colorado is about two thousand miles. The area drained by the Colorado and tributaries contains about three hundred thousand square miles, a region larger than all the New England and Middle States, with Maryland and Virginia. The lower part of the Colorado basin is in general but little above the sea level. The upper part, for two thirds the length of the stream, is a region varying from four to fourteen thousand feet above the level of the sea. Through this high region of solid rock the streams have cut, making a land of plateaus and intervening cañons many thousands of feet deep. While the descent of the Ohio River from Pittsburg to its junction with the Mississippi is four hundred and twenty-six feet, the descent of the Colorado an equal distance, or from Green River station to the lower plain already referred to, is five thousand feet. Such figures speak for themselves; it is not necessary to enlarge upon the violent action of such a stream, pent between mountain walls, filled with gigantic bowlders, and rushing with the velocity of a mountain torrent.

They have not far to go before the difficulties of the voyage commence, and they are obliged to make frequent portages around falls, to shoot perilous rapids, and to swing the boats past dangerous rocks by lines. On the 9th of June they reach a fall where they determine to make a portage, and three of the boats make a successful landing above the fall. The fourth boat is in mid-current; there is no time to land, and the boat and its crew of three men are instantly swept over. The fall is about twelve feet high, not greater than others which the party have shot over with safety before, but below is a rapid, full of rocks that beat the roaring waters into foam. The instant the terror-stricken observers see the boat emerge from the foot of the fall, it is dashed against a rock and broken in two, the men still clinging to the larger fragment. On they are hurled, and the remaining piece is crushed. One of the men is washed upon an island, another clings to a rock in a whirlpool, the third is caught bruised and fainting among rocks far down the stream. This their first disaster occurred in a cañon to which they gave the name of Lodore, the entrance of which is shown by Fig. 4 (see next page).

In the same cañon they reached a continuous succession of rapids half a mile long, the river full of huge bowlders. By excessive labor they were able to let the boats down by lines, one by one, with no greater mishap than the breaking away of one of them, which by great good fortune was caught in a whirlpool below. This stretch of river they named Hell's Half-mile.

Even in camp the party were not safe They camped one night under the willows in a little park which filled an alcove in the cañon. A whirlwind came, scattered their blazing fire among the under-brush, and the conflagration was so sudden and fierce that the men were forced to jump into the boats and cut loose, abandoning blankets and other baggage in their haste.

Nearly a month has gone by since the start, consumed in tedious and laborious progress, the boats frequently overturning and swamping in the crested billows of the rapids, the oars often lost, and new ones as often made from the chance driftwood, the barometers broken and refilled. On the 21st of June they enter a cañon to which they give the name of Whirlpool. The little party are hurled along with unusual rapidity, and soon the roar of a cataract is heard. The walls of the cañon are vertical and smooth, the river fills the whole space between them, and there is no landing-place. The men instantly row to the sides of the cliffs, and there, but fifty feet above the fall, only by the utmost exertion are they able to hold the boats against the rock by hard rowing, while the swaying current every instant threatens to sweep them down. At last one of the men discovers a crevice in the rock, into which he crawls and secures the lines of the boats. Finally, by other crevices, Prof. Powell is able to reach broken rocks on the brink of the fall. To these the boats are let down by lines, then carried by the men over the broken fragments to a point below the falls; and thus is ended another chapter of Prof. Powell's remarkable narrative. Such was the daily experience of the explorers. Every new cataract or rapid presented a new engineering problem or taxed the daring of the navigators to some new feat.

On the night of June 12 the party camp on a sandbeach in Gray Cañon, as they named it. The wind blew a hurricane, the blinding sand drifted all night, sifting through their blankets and covering them as by a snowdrift. In the same cañon they were obliged to collect pitch from the scanty pines to calk their boats, which, though very strong, had become leaky by the severe strains.

But there were not wanting scenes to repay their hardships. They had walked by the river on mosaic pavements of brilliant minerals, and watched for miles the gorgeous colors of the Vermilion Cliffs. They had slept in vast rock-domes, and seen many works of nature's architecture, buttressed and terraced by many-colored strata. On the 9th of August, while in Marble Cañon, Prof. Powell writes: "Riding down a short distance, a beautiful view is presented. The river turns sharply to the east, and seems inclosed by a wall set with a million brilliant gems. What can it mean? Every eye is engaged. Every one wonders. On coming nearer we find fountains bursting from the rock, high overhead, and the spray in the sunshine forms the gems which bedeck the wall. The rocks below the fountains are covered with mosses and ferns and many beautiful flowering plants. We name it Vasey's Paradise, in honor of the botanist who traveled with us last year."

The progress of the little party was still varied by frequent calking of boats, making of oars, climbing cliffs, when accessible, for barometric observations, swamping in rapids and shooting falls. Owing to frequent wetting their bacon and flour were spoiled, and much had to be thrown away. Each day diminishes their scanty stores; each day brings them nearer the region most dreaded of all, the Grand Cañon of the Colorado. The nights are cold and rainy; blankets, rubber ponchos, and hats are lost; not a man has an entire suit of clothes. On the 28th of August, having reached a place where they could climb out of the gorge, three of the men decided to abandon the expedition and strive to reach the Mormon settlements on the plains above. To those still determined to go on it was a solemn parting; letters were written to absent wives; watches and trinkets were given in charge for sisters far away, and the records of the expedition were intrusted to the departing comrades.

The departure of the three men demanded the abandonment of one of the boats and some baggage, fossils, and minerals. The men had long ago learned to watch the texture of the rock. In soft strata they found a quiet river; in hard, rapids and falls. Where the strata are horizontal, the river is unobstructed and often quiet. Where the rocks incline in the direction of the current, though the stream is very swift, there are few falls. But where the rocks dip up stream, and the river cuts across the upturned formations, harder strata often above and softer below, there are dangerous rapids and falls. On the 14th of August the party enter just such a stretch of river, with harder rock than they had yet known. The river enters the granite. The walls rise to a height of six thousand feet. Stand on the south steps of the Treasury Building in Washington, and look down Pennsylvania avenue to the Capitol Park, or stand at Canal street in New York, and look up Broadway to Grace Church, then imagine such a vertical distance, more than a mile in altitude, and a faint conception is got of the immensity of these cliffs. The men are entering the Grand Cañon, Fig. 8 (see page 1871.)

The boats are tossed like bubbles on the heaving, swaying flood, now one ahead, now another. No order is preserved; the voice of command is unheard in the unceasing roar; each crew labors for their own preservation. The men have been whirled for months through gigantic solitudes, but to the unutterable grandeur that awes them now no other scene has approached.

FIG. 1.—THE CAÑONS OF THE COLORADO.—GREEN RIVER.

They find that though the cañon threatened them, their further progress is no more perilous and laborious than heretofore. To instance the mishaps that had become common to them, let us quote from Prof. Powell's diary of August 28: "Just after dinner we come to another bad place. A little stream comes in from the left, and below there is a fall, and still lower another fall. Above, the river tumbles down among the rocks, in whirlpools and great waves, and the waters are lashed into mad white foam. There is a bed of basalt along the northern side of the cañon, with a bold escapement that seems a hundred feet high. We climb it and walk its summit to a point above the fall. Here the basalt seems broken down, so I direct the men to let the boats down to the broken place above the fall, to make a portage. Further inspection proves that the broken place is below the fall, so a portage is impossible, and the river is very bad below. I run back to prevent letting down the boats, but am too late. The men have let one of them down to the head of the fall. She is in very swift water, and they are not able to pull her back, nor are they able to go on with the line, as it is not long enough. I send two men back for the other line. The boat is in very swift water, and Bradley is standing in her, holding out his oar to prevent her striking the cliff. Now she shoots out into the stream, as far as the line will permit, and then, wheeling, drives headlong against the rock. The second line is brought and we pass it down to Bradley, but he is so occupied that he does not see it. I stand on a projecting rock, waving my hat to attract his attention, for my voice is drowned in the roar. Just at this moment I see him unsheath his knife and spring forward to cut the line. He has evidently determined that it is better to let the boat go over the falls than to wait for her to be broken to pieces. As he leans over, the boat sheers again into the stream, the sternpost breaks away and she is loose. With perfect composure Bradley seizes the great scull oar, places it in the stern rowlock and pulls with all his power (and he is an athlete) to turn the bow of the boat down stream, for he wishes to go over bow first rather than broadside on. One, two strokes he makes, and a third just as she goes over. Down she shoots, almost beyond our sight, though we are more than a hundred feet above the river. Then she comes up again on a great wave, then down and up, then lost in the mad foam below. We stand frozen with fear, for we see no boat. But now, far below, we see something coming out of the waves. A moment more we see Bradley standing on deck. But he is in a whirlpool. The sternpost of his boat is attached to our line, and how badly she is disabled we know not." The boat was recovered, however, and put in sufficiently good condition to continue the voyage. Bradley was uninjured.

This was their last adventure. At noon of the following day they emerge from the Grand Cañon. They were now in open country, traversing a stretch of river comparatively well known, and not far from settlements. "The relief from danger and the joy of success are great. Ever before us has been an unknown danger, heavier than immediate peril. We have watched with deep solicitude the disappearance of our scant supply of rations; and danger and toil were endured in those gloomy depths, where oft the clouds hid the sky by day, and but a narrow belt of stars was visible at night. Only in the few hours of deep sleep has the roar of the waters been hushed. Now the toil has ceased; now the gloom has disappeared; now the firmament is bounded only by the horizon, and what a vast expanse of constellations can be seen."

Fig. 2.—PA-RU-NU-WEAP CAÑON AND THE RIO VIRGEN, A TRIBUTARY OF THE GREEN. DEPTH OF CAÑON FROM 600 TO 1500 FEET.

Fig. 3.—MARBLE CAÑON. THE WALLS 2500 FEET HIGH, POLISHED BY RAINS, AND SHINING WITH MANY BEAUTIFUL COLORS.

Fig. 4.—GATE OF LODORE. ABOUT 2000 FEET DEEP.

Fig. 5.—GYPSUM CAÑON, A SIDE CAÑON.

THE GRAND CAÑONS OF THE COLORADO RIVER.

FIG. 6.—CAÑON OF THE KANAB, A TRIBUTARY OF THE GREEN, 3000 FEET DEEP.

FIG. 7.—VIEW AT THE MOUTH OF THE LITTLE COLORADO.

THE BLACK HILLS.

WHERE THEY ARE—HOW TO GET THERE.

WE are constantly in receipt of letters from parties in various sections of the country, seeking information concerning the new and wonderful territory, its past, present and probable future, conditions of society, means of ingress, etc., and as to answer each and every one would keep a correspondent in constant employment, we have prepared the following brief statement, which may be relied upon as correct:

The Black Hills are located 200 miles north of the Union Pacific Railroad, and are reached from Chicago via the Chicago, Burlington and Quincy, the Chicago, Rock Island and Pacific, or the Chicago and Northwestern Railroad from Chicago to Omaha, 500 miles; the Union Pacific Railroad to Sidney, 414 miles, or to Cheyenne, 516 miles, thence by a first-class stage line to Deadwood and principal camps in the Hills. Time necessary for a trip from Chicago to Deadwood, four and a half days. Fare, $49.25, first-class. By this route but two changes are made between Chicago and destination—at Omaha and Sidney or Cheyenne. Accommodations, including the stage lines, are unsurpassed. Another route is via the West Wisconsin or the Chicago, Milwaukee and St. Paul line to St. Paul, and the St. Paul and Pacific and Northern Pacific to Bismarck, from whence a tri-weekly line of coaches depart for Deadwood, distance 250 miles. Time by this route, six days from Chicago; fare, $49.25.

Deadwood is the most northerly mining camp in the Hills, of which it is the metropolis, and is located eight miles from the foothills, at the confluence of Deadwood and Whitewood creeks. The gulch proper contains a population of about 4,000 people. The city, for a mining camp, is substantially built, and is daily improving. Business of all kinds is well represented, and society will compare favorably with any mining town in the West. We have two churches, school houses, two daily papers, telegraph, two daily mails, excellent hotels, and business houses of all kinds. We have no municipal government at present, but steps have been taken for the establishment of a corporate city. At present we are under the exclusive dominion of county officials. The mining interests of Deadwood City are exclusively placers, and are of the richest quality; but recent quartz discoveries upon Spruce Gulch, two miles south, and Elk Creek, 20 miles southeast, with the already famous silver district known as the Bear Buttes, and the gold region of Strawberry Gulch upon the north and east, render the city a direct central point. Four miles west lies the wonderful cement belt, upon which are located the most thoroughly developed gold quartz mines in the Hills. Central City, South Bend and Gayville upon Deadwood, and Lead City upon Gold Run, are the other principal camps in this section. Their interests are chiefly quartz mining and milling, albeit their placer claims have yielded handsomely for two seasons. In the districts named there are at present upward of 40 mills or 600 stamps in constant operation, day and night, a number that is being daily increased. The ore pays from the surface down, and at an average of about $12 per ton, and as it can be mined and milled for one-half that sum, the profits may be easily computed. Land is far from all being taken up, locations being made every hour in the day, besides which valuable property can be purchased at reasonable rates, owing to the inability of many poor miners to work it.

The Bear Butte silver district is distant about 10 miles, and is equal in richness to any in the world. One smelter is in operation, and others will shortly be erected.

Rapid City, 45 miles southeast of Deadwood, on the Sidney stage route, is delightfully located in a picturesque valley, and has, in addition to large mineral interests, agricultural resources of the very best. Twenty five miles further south are camps Hayward and Rockerville, in the center of newly discovered, very extensive and very rich quartz, gulch and dry mining districts, where there is abundance of room for thousands of locations, which will undoubtedly be made during the coming season. Still further south lies French Creek, Custer City, and a large mineral district—the southern extremity of the belt—which is idle at present, owing to the fact that claims elsewhere can be worked more cheaply. In a year or so French Creek will be developed, and we predict that when that time arrives the result will astonish "the oldest inhabitant." The climate of the Hills is very salubrious and the health of our cosmopolitan population is surprisingly good. The expense of living here is, all things considered, very reasonable. Hotel rates are $3 and $3.50 per day, or $18 per week, but as all save transient people sleep in their places of business and merely pay $10 per week for table board, individual expense accounts are comparatively light.—*Black Hills Times.*

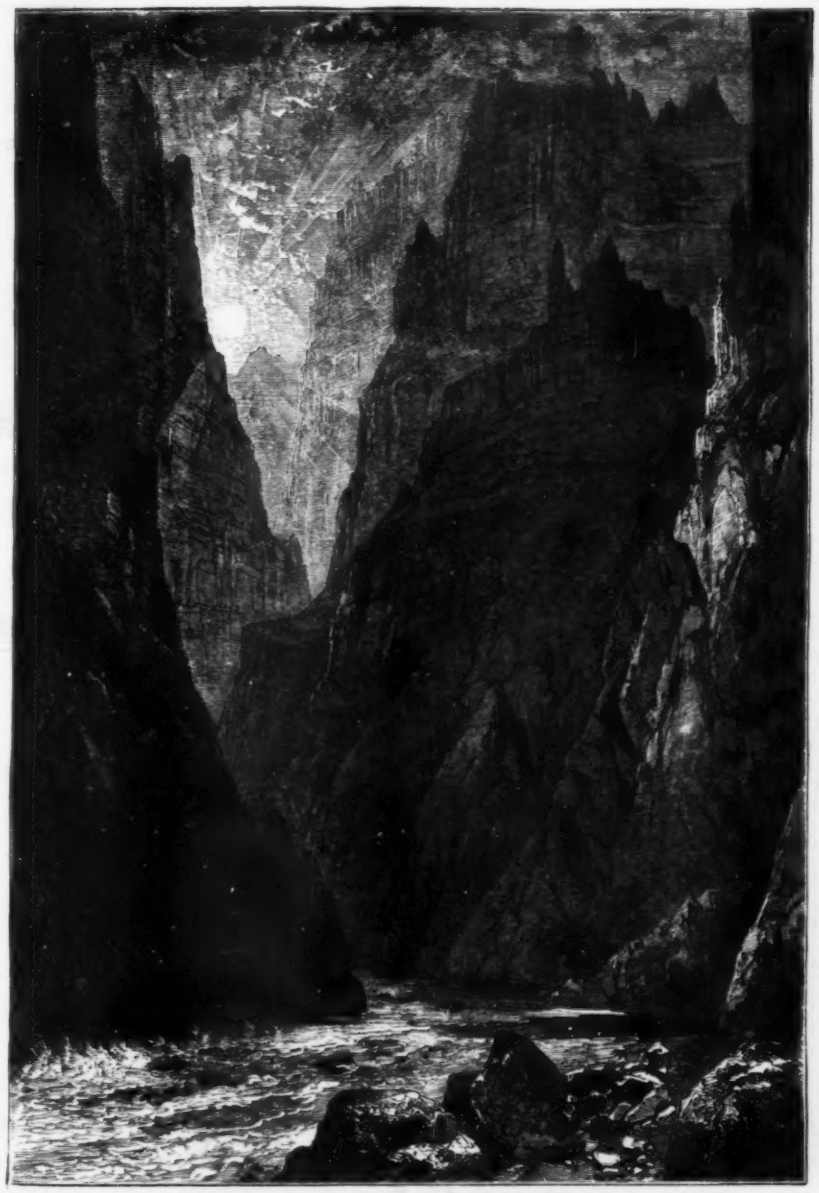


FIG. 8.—GRAND CAÑON OF THE COLORADO.

THE GRAND CAÑONS OF THE COLORADO RIVER.

Fig. 1.—BETON BRIDGE—CLEFTRIDGE SPAN.

Fig. 2.—PORTAGE VIADUCT, ERIE R. R.

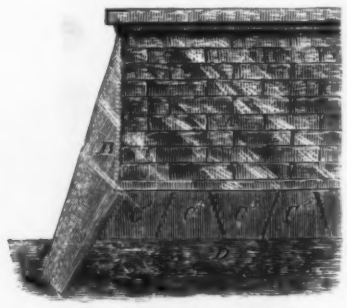


Fig. 3.—PORTAGE VIADUCT PIER.

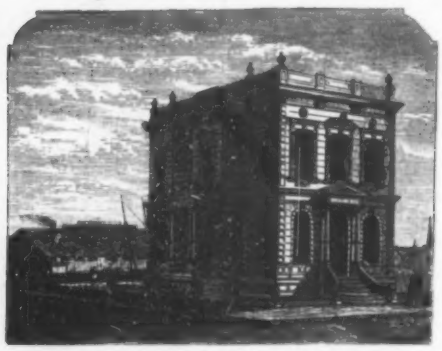


Fig. 4.—BUILDING OF BETON, BROOKLYN, N. Y.

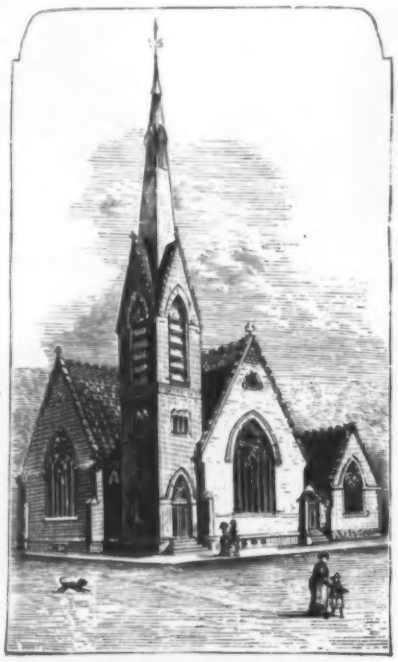


Fig. 6.—BETON CHURCH.

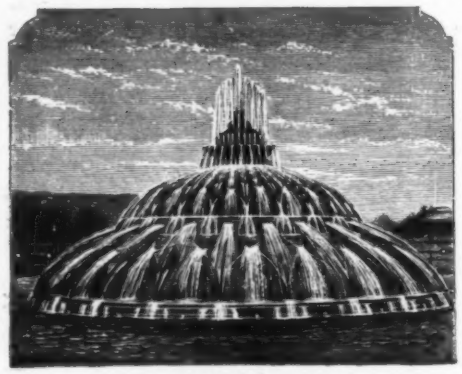


Fig. 7.—BETON FOUNTAIN.

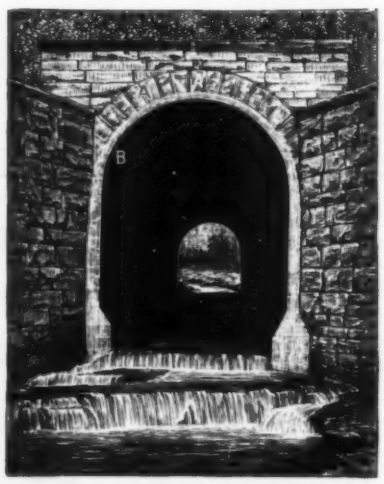


Fig. 8.—BETON CULVERT LINING, ERIE R. R.

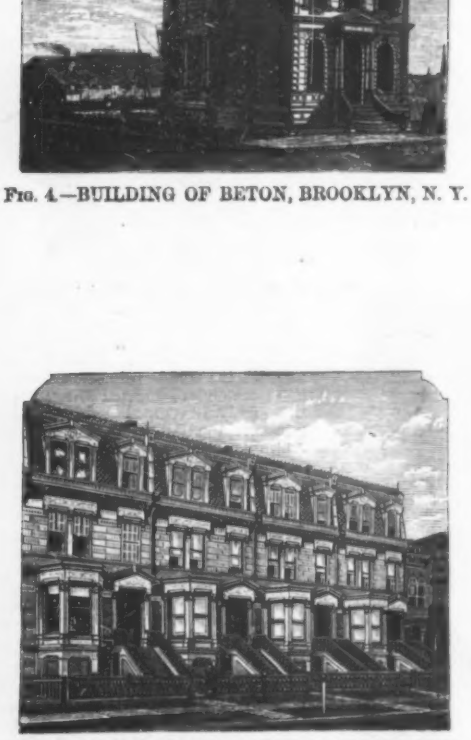


Fig. 5.—BETON DWELLINGS, BROOKLYN, N. Y.

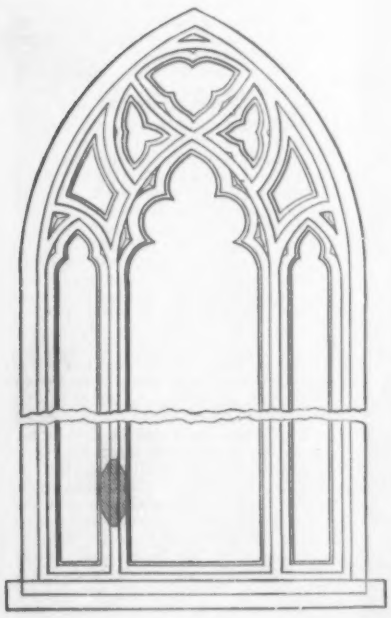


Fig. 9.

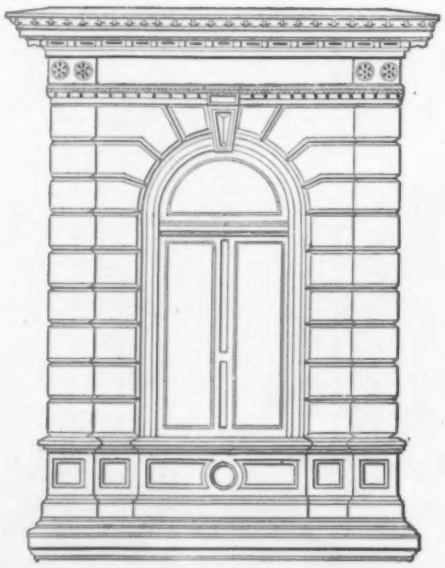


Fig. 10.

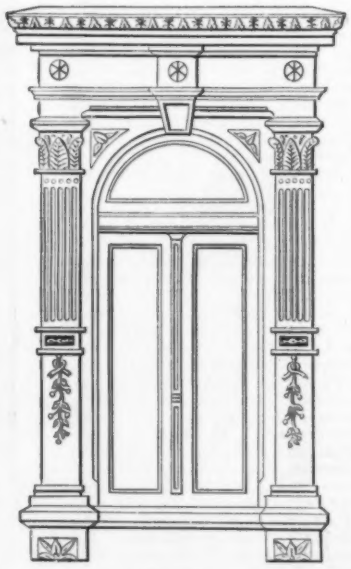


Fig. 11.

EXAMPLES OF ARCHITECTURAL AND ENGINEERING WORKS IN BETON CONCRETE.

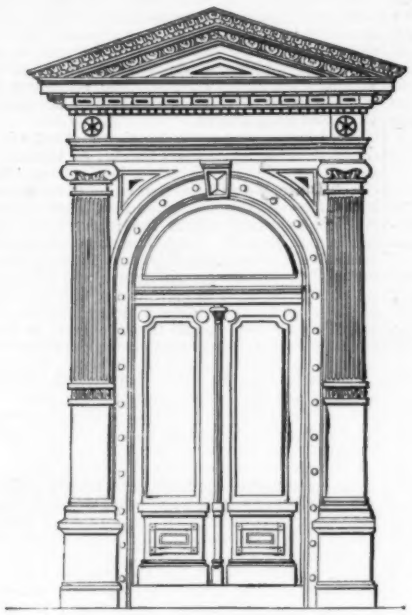


FIG. 12.

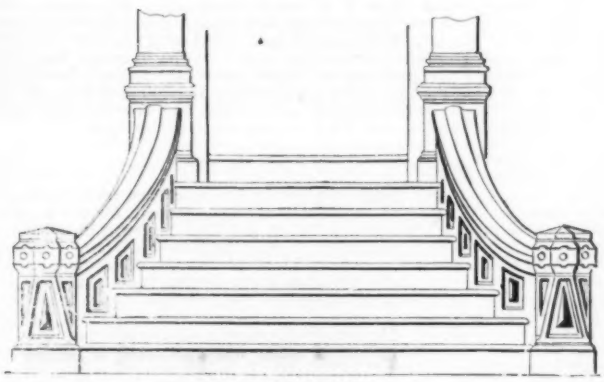


FIG. 13.

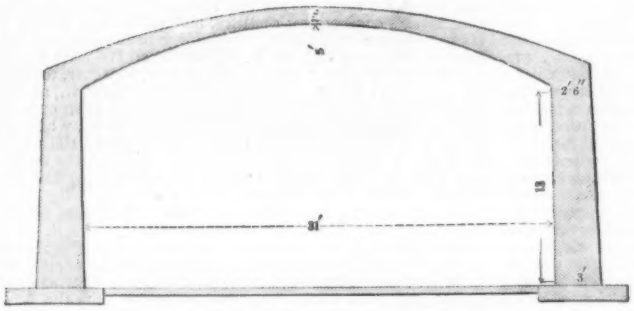


FIG. 14.—BETON TOMB.—ARCH 31 FT. SPAN.

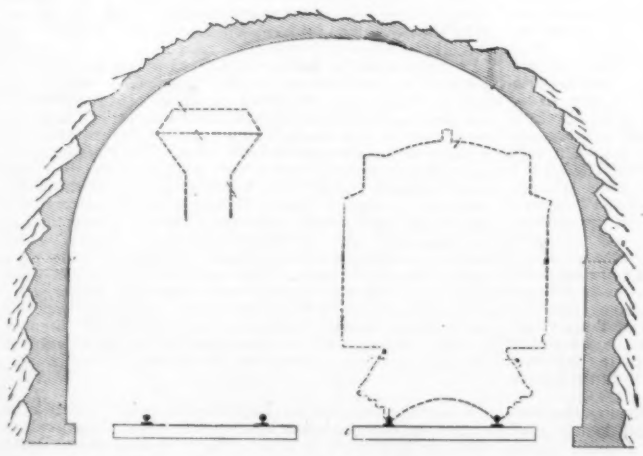


FIG. 15.—BETON LINED TUNNEL, ERIE RAILWAY.

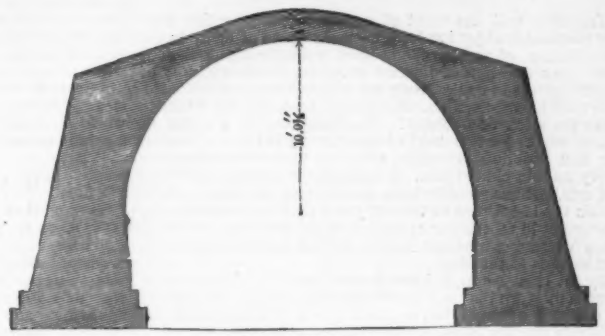


FIG. 16.—BETON RAILWAY TUNNEL.

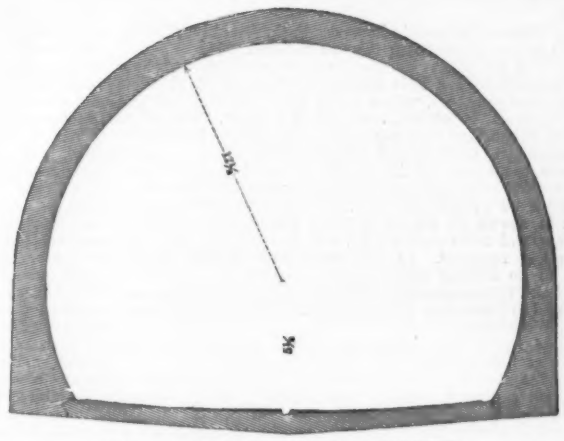


FIG. 17.—BETON RAILWAY TUNNEL.

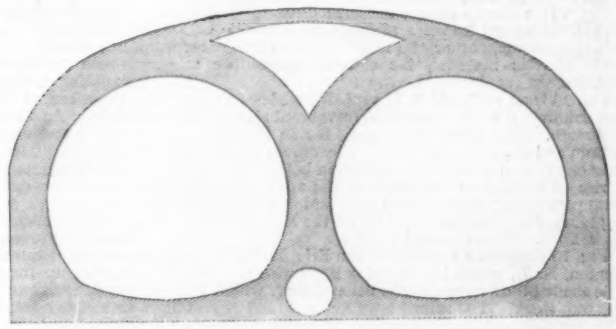


FIG 18.—BETON DOUBLE RAILWAY TUNNEL.

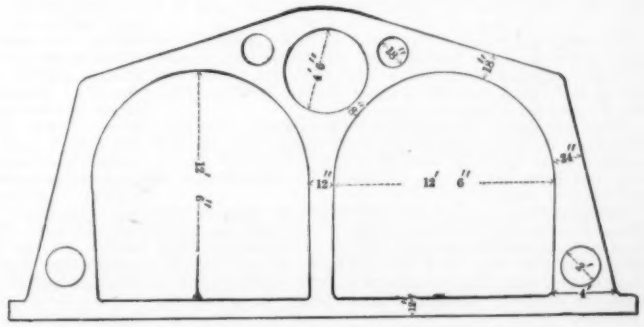


FIG. 19.—BETON DOUBLE RAILWAY TUNNEL.

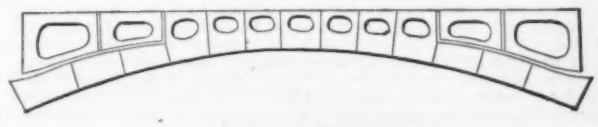


FIG. 20.—BETON FLOOR ARCH.

EXAMPLES OF ARCHITECTURAL AND ENGINEERING WORKS IN BETON CONCRETE.

BETON CONCRETE IN BUILDING.

[FOR ILLUSTRATIONS SEE PRECEDING PAGES.]

TIMIDITY and the want of a full precedent rather than any reasonable objection have been the cause of delay in the introduction of many of our most valuable materials. It would be a question of interest to follow the slow history of improvements in engineering and architecture and the materials used in construction. How many centuries did it take to make the brick of our day? We illustrate, by a series of cuts of works constructed in beton, the varied uses of one of our best building materials, and one that was most extensively used in olden times. It had almost become one of the lost arts, but has recently been revived and perfected. Until within the last fifteen or twenty years there has been no improvement in mortars or concretes since the time of Pliny, when Vetruvius wrote on mortars a book that is standard on that subject to this day.

By the term beton, a French word anglicized, we understand a mixture that may be of the same composition as that of ordinary concrete, but one that has a more careful and elaborate manipulation.

We do not in this article intend to explain this process (which has already been done in our columns), but by a series of illustrations to show the adaptability of this material to various uses. For this purpose we have selected a series of views, taken from photographs, of the structures erected by Mr. John C. Goodridge, Jr., President of the New York Stone Contracting Company, of Third avenue and Sixth street, Brooklyn, N. Y. This establishment is the oldest and largest manufactory of beton in the United States.

Fig. 1 shows the arch in Prospect Park, Brooklyn, N. Y., known as Cleftridge Span; it was erected in 1871.

Fig. 2 is the great viaduct over the Genesee River, where it is crossed by the Erie Railway at Portage, N. Y. The present iron structure, which is 850 feet long and 240 feet high, replaces the wooden one burned in 1875. The stone piers of this bridge were so far destroyed by the burning of the fire that, in order to make them secure, it was necessary to have them encased in beton, and the injured portions were removed and replaced with that material. The piers are from 90 to 180 feet long. The manner of doing this work is shown in Fig. 3, A being the pier, B the beton buttress, and the sections C C', etc., the portions that were alternately removed. In making repairs in this manner there is no settling and no risk; buildings may be undermined and the foundation extended. This method has been proposed in increasing the base of the Washington Monument, Washington, D. C.

Fig. 4 shows the building corner of Third avenue and Sixth street, Brooklyn, N. Y., erected in 1871.

Fig. 5, a row of dwellings in Clinton avenue, Brooklyn.

Fig. 6, a church, selected out of about thirty, erected wholly or in part of this material.

Fig. 7 illustrates the beautiful fountain on the plaza at the entrance of Prospect Park, in Brooklyn, erected in 1872.

Fig. 8 is a culvert on the Erie Railway at Warsaw, New York. This arch was under a "fill" of 68 feet, and was caving in; further disintegration was prevented and the arch supported by a lining of beton 4 inches in thickness. This was done in 1875. The arch is now perfect and perfectly dry. It is 18 feet in height and 150 feet long.

Figs. 9, 10, 11, 12, 13, arches, etc., in beton.

Fig. 9 is a church tracery made in 1870. The clere-story arches, ashlar and traceries of the great Catholic cathedral on Fifth avenue, corner of Fiftieth street, New York, were made of this material, the contract amounting to over $40,000.

Fig. 14 is an arch which is probably without a parallel in this country; it is 31 feet span, 5 feet versed sine, and 60 feet in length. The bench walls are 3 feet in thickness at the bottom and 2½ feet at the top. The crown of the arch is only one foot in thickness. Arches in beton need not have a rise of more than one-tenth of the span, the monolithic form preventing thrust. This structure is used as a receiving tomb, and is in the Cemetery of the Evergreens, at East New York. It was erected in 1872.

Fig. 15 represents a section of the Erie Railway tunnel at Bergen, N. J., which is now being lined with this material. The shaded lines represent the beton lining, which is about one foot thick. The tunnel is 28 feet wide and 21 feet high. This most difficult work is carried on without stopping the trains.

Figs. 16, 17, 18, 19, designs for underground railroad, on both single and double tunnel plans. The double tunnel is more expensive, but is presumed to afford better ventilation. This material is particularly adapted for this purpose, as it is impervious to moisture, and it can be safely carried under existing structures.

Fig. 20 shows an arch between iron beams, used in the Art Museum in Central Park, New York. The span is 9 feet.

It is proposed to use this material in lining a shaft 1,200 feet in depth. Recent experiment, under the supervision of two of our most distinguished mining engineers, proved this beton to be impermeable to water under a pressure of 150 lbs. to the square inch.

This material is also adapted for pavements. The plat forms at the Pennsylvania depot in Jersey City, and the walks around Worth Monument, at the junction of Broadway and Fifth avenue, may be instanced as illustrations of this class of work.

We present these facts not to prove by any theories that beton may be used, but to show that it has been used most successfully, and that for nine years it has thoroughly withstood fire and water and the action of our climate. We make the foundations of all our important structures of common concrete, yet look with hesitation on a superior product.

While beton is as well adapted as natural stone to all classes of architecture and engineering, it has a province of its own not shared by other materials. This is largely due to the fact that of it we can make monolithic structure in arches or dams or breakwaters of ordinary masonry. The removal of a stone weakens the whole mass; the loss of a single stone in a dam may allow the water to wash away the whole of it; a crumbling stone may cause an arch to fall; a monolithic arch has no thrust; the weight is evenly distributed.

Our illustrations, though the most complete that have ever been published, show but a small representation of the quantity of beton used; it has been the desire to represent the varied kinds of structures, and not a repetition of the same class.

Beton is cheaper than brick or stone; it is far stronger. Beton stands a crushing strength of from 8,000 to 10,000 lbs. per square inch; brick stands less than 2,000 lbs.; about one-quarter of a brick structure is common mortar. Beton monoliths have no weak joints. They can be erected with great rapidity; there is no unequal settlement. It is waterproof and fireproof. With these advantages we look to a near future when it will become the popular building material. Nothing prevents its exclusive use in certain classes of structures but the natural repugnance to anything new. The same spirit that held back the printing press, the use of steam, and the telegraph, and told blind Galileo that the world did not move, stands in the way of every labor-saving machine and of every new project.

CHICAGO AND ITS ARCHITECTURE.

THE earliest known records of Chicago date back to 1669, when La Salle and Nicholas Parrot, two French missionaries, visited the Indians. In 1804 the American Government built Fort Dearborn, but evacuated it in 1812. It was rebuilt in 1816, and finally demolished in 1856. Chicago was first incorporated as a town in 1837, just forty years ago, when an official census gave the population at 4,170. In 1850 the population had risen to 29,963; in 1860, to 112,172; and in 1870, to 298,977. To-day it is estimated at 536,673.

So far the growth of the city had been rapid and astounding, but in 1871 it passed through the crisis of its existence, and from that year we can almost date a new era. It was devastated by a fire, perhaps one of the greatest conflagrations the world has ever witnessed, which laid waste over 3½ miles of streets, rendered a hundred thousand people homeless, and destroyed property worth about $200,000,000. "Rome was not built in a day," the sages are fond of telling us, but here it really seemed as if a city, like the phenix of old, would rise from the ashes of the dead. Let English readers imagine the whole of Threadneedle, Lombard, Leadenhall, and Bishopsgate streets, Cornhill, Cheapside, and the Poultry suddenly laid in ashes, and they will be able to form some idea of what the effects of the fire at Chicago were. It was absolutely necessary to begin rebuilding at once, and although many people were made bankrupt through losses on insurance and other causes, yet the trade of Chicago was so well established that it was apparent that it would only suffer a slight suspension until her merchants were ready to begin again. Money flowed in from all sides, and with a most surprising activity and energy. Hardly before the ashes had cooled the *débris* was being cleared away and preparations made for laying new foundations. The Chicagoans were alive to the necessity of improved streets and so-called fireproof structures, and determined to erect edifices that would reflect credit on their taste. Seldom, indeed, has a modern city had an opportunity like this, which should have been seized, so that by a vigorous treatment Chicago might really have become "the finest city, in an architectural sense, in the world." This is what her inhabitants modestly call her, and by the united action of her architects much might have been achieved; but, instead, every man built according to his own idea, and so shams and inconsistencies stand forth boldly and meet the observer at every street corner.

We will commence our inspection at the north end of State street (the Broadway of Chicago) and proceed southward. We must first take a glance at the position of the city. It is divided by the river into three great portions (popularly termed "sides"), and has a water frontage on lake and river of 38 miles. The principal streets, as in all large American cities, run at right angles to each other, the river being the basis for each side. The first building of any note is the "Windet Block," a structure not deserving much notice except in the way of censure. The next building worthy of notice is the "Singer Block," a very large one, at the corner of two streets, in the Renaissance style. As the building has lately been burnt down, and is now a complete ruin, we forbear to criticize it, and therefore pass on. The First National Bank Building, at the corner of Washington street, is also in the Renaissance style. The block has a canted corner which is well treated, and made a conspicuous feature. On the first floor is a boldly projecting arch, and inside this arch is the window with a pediment over. The next block is rather striking. The superstructure is commonplace, but the roof, after a fashion, makes up for everything. The roof is a very heavy mansard, with two rows of dormers. In the center of the building rises a very heavy pediment. Under this pediment is a large two-light window, with pediment, cornice and finials. Above these windows is another row, very similar, only smaller. The fenestration is too obtrusive. Opposite this block is a large Italian building. The engaged columns are in all cases carried up two floors. Although presenting an imposing front, it is too overloaded, no opportunity for decorating finials, brackets, or keystones having been lost. Passing on southward we come to the building of Chicago, "The Palmer House." This magnificent pile presents two very imposing facades in State and Monroe streets. The treatment is free Italian, although the ground floor is Greek Doric, the upper floors Corinthian. Three well-sculptured groups crown the main entrance. The building finishes off with a heavy mansard roof and two rows of dormers. Entering the main entrance in State street we come into the grand hall, 28 ft. by 70 ft., supported by Ionic columns. It is elegantly wainscoted with marble, no less than 34 kinds being used. At the end of the hall we ascend two marble steps and enter the rotunda. It is elegantly proportioned, supported by Corinthian columns elaborately worked. On the left of the grand hall the principal staircase, constructed of Carrara marble, rises to the entresol floor. This staircase is a marvel of architectural skill. It is an open-neweled staircase, and entirely self-supporting. Each step and landing is cut out of a solid block of marble, and so accurately jointed and fitted that it forms one solid mass. The staircase leading to the whispering gallery in St. Paul's is the only other one in the world constructed on this principle. The grand dining hall, restaurant, and grand parlor are all worthy of notice. One of the "bridal chambers" reminds us of Amy Robsart's room at Cumnor Place. The furniture is unique and costly—the carpet is of the softest and most delicate materials—rare articles of *virtu* are strewn about, and handsome paintings adorn the walls. Cupids, doves, wreaths of flowers, and other appropriate emblems look down on the votaries of Hymen. The bed is surmounted by a canopy in the French style, and a thin filmy vail of lace reaches from the canopy to the floor.

On Wabash avenue "Aiken's Block" is the first that fixes our attention. The cornice over the ground floor is good. On the first floor we find Ionic pilasters, a dentil course, and a heavy cornice, supported by four rather well-sculptured caryatides. The two upper stories are very weak and flimsy. The dentil course is continued round the pediment, and it is as usual cut and a console inserted. One of the few relics of the great fire claims our attention a little higher up in the shape of one side of a church. Here the same fault is patent as in most other Chicago buildings—inconsistency. The church is too ruined to criticize at length: it is enough to say that the nave windows are late Early English, or rather of the transitional period between debased Early English and Early Decorated, while the clere-story windows are Early Lancet. The buttresses are Early English, stepped and carried right up to the cornice, which is weak and insignificant.

Washington street, the Lombard street of Chicago, next demands attention. The Chamber of Commerce is built of gray Buena Vista sandstone (a local stone). The entrance is Greek Doric, with Corinthian columns over, and large circular windows. The Exchange Hall is 142 ft. by 87 ft. and 45 ft. high. On each side of the rostrum are frescoes representing allegorically the destruction of the city by fire. "The Methodist Church Block" is pure Tuscan, but is (naturally) too solid for business architecture, and out of keeping with its surroundings. The office of the Chicago *Times* is another of the remarkable buildings Chicago architects have evolved. It baffles description, and must be seen to be appreciated. Corinthian (?) columns support the doorway, and the general style of the ground floor is Corinthian. On the first floor we find Tuscan pilasters, with a small stone dentil on the same, but nowhere else. The second floor has perfectly plain pilasters. The third floor boasts round windows. The fourth floor completes this *pot-pourri* by introducing four centered Perpendicular windows, with stone mullions. It also boasts a pediment, several cantilevers, a balustrade, and a cornice. Rickman censures the architect who piled all the orders on the schools at Oxford. But what would he have said to the man who, in addition to piling up all the orders, gives us a slice of Gothic as well? A building of quite another style is that occupied by the Third National Bank. It is of red brick, with stone dressings and window heads, cornices, and balustrade. It is boldly treated, and contrasts very favorably with some of the more pretentious, pseudo-classic structures. In Clark street I can notice but two buildings. "The Lakeside Building," Renaissance in type, though not strictly pure, is, on the whole, bold and effective. Some of the windows have heavy square Tudor labels, and altogether a strong Tudor feeling pervades the whole. Over each side of the entrance doorway are pedestals and canopies, but no statues, which gives it rather an unfinished appearance. The "Reaper Block" is debased Classic, Corinthian and Tuscan mixed. The mansard roof and heavy dormers are out of keeping with the other parts. "The Tremont House" in Lake street, a splendid specimen of the Italian school, is one of the purest and most consistent buildings in Chicago. The design has been well carried out, and is well suited to the building.—A. W. L., *in London Building News.*

PROPOSED NEW HARBOR WORKS FOR GREENOCK.

CONSIDERABLE progress has now been made by Mr. W. R. Kinipple, C.E., with the arrangements for the construction of the new wet dock and tidal harbor, which has been so long in contemplation by the Greenock Harbor Trustees; indeed, it may be said that the plans, specifications, and bills of quantities for this new engineering undertaking are practically completed, and they will very shortly be issued from the harbor engineer's office in a collected form for the information of intending contractors. When it is considered that the total cost of the works now contemplated will probably be not less than £300,000, it is but natural to suppose that not a few contractors will, in consequence of the somewhat dull times now existing, make a strenuous effort to secure the job. A number of them are certainly looking forward to it with a considerable amount of interest.

The site chosen for the new dock is at Garvel Park, close by the graving dock which Mr. Kinipple designed and constructed for the Greenock Harbor Trustees a few years ago, and which has reflected such an amount of credit upon that gentleman's engineering abilities, and added very greatly to his professional reputation. According to the plans there is shown a wet dock of 2,000 ft. in length and 300 ft. in width, the Harbor Trustees retaining the power, however, to limit the length to 1,600 ft., 1,700 ft., 1,800 ft., or 1,900 ft., as may eventually be deemed most desirable. At the main or western entrance to the dock the width is to be 70 ft., while the depth of water on the sill at high water of spring tides is to be 28 ft.; and there is also to be an opening at the eastern end 40 ft. in width, and having a depth of 16 ft. of water on the sill. Within the wet dock there is to be a jetty 40 ft. wide, and ranging from 600 ft. to 1,000 ft. in length, according to the length ultimately chosen for the dock itself. Provision is made in the specifications for a new tidal harbor of somewhat larger dimensions at the western end of the wet dock, and for the formation of a river wall, embankment, quays, and other works connected therewith "on the lands and foreshore of Garvel Park Estate, and the lands and foreshore to the east thereof, belonging to the Greenock Harbor Trustees, and situate on the banks of the Clyde at the eastern end of the town of Greenock." It also provides that the contractor for the works, not later than the end of the second year after the date of the order for commencement of the work, shall prepare a site on the bottom of the wet dock for the use of the contractor who is to construct the caisson which is to be used at the western entrance of the wet dock. With the exception of this caisson all the other ironwork is apparently included in the specification. From the experimental borings which have been made, and which are specially detailed in journals in the engineer's office, it would seem that the strata upon the site of the docks consist of "till," bowlders, and sandstone rock, and the excavations from the dock are to be deposited so as to form a river embankment or quay, or be conveyed to Loch Long. The river embankment referred to is, of course, the proposed new river line from Ladyburn Perch to the western entrance of the dock, which the Greenock Harbor Trustees are at present very anxious to have settled, and regarding which negotiations are in progress with the Clyde Lighthouses Trustees. Until that line is settled it will practically be impossible to push forward the other works. The superstructures of the walls of the wet dock, the entrance works, the tidal harbor, etc., are to be executed in Portland cement and rubble concrete and Portland cement brickwork, faced and coped throughout with granite. An important item in the specification is that the contractor must find £35,000 security—*Engineering.*

PARISIAN ELECTRICAL LIGHTS.—A project which is at present in contemplation by the Commissariat-General of the Paris Exhibition is to fix on the towers of Notre Dame two powerful electric lights, the rays of which, thrown in the four cardinal directions, will illuminate the public buildings. The lights are to act once or twice in the week, from 10 p.m. till midnight.

TOMLINSON'S SELF-OILING JOURNAL-BOX—FOR CAR AXLES, SHAFTING, SAW MANDRELS, &c.

THE lubrication of the running parts of machinery effectively and economically ranks among the most important questions in mechanics. Wherever one part or member of a machine moves upon another, the frictional resistance of the two surfaces causes a retransmutation of work into heat, to be conducted and radiated away by the metal or material of the parts, and all heat produced in this way is so much clear loss of the energy derived from whatever motor impels the machine. A loss of energy proportional to the heat evolved is not, however, the only economic aspect of the case. Where the friction is excessive, the parts in contact themselves suffer abrasion and wear, and, aside from the mere cost of renewal of such worn parts of a machine, large money losses are often caused by the consequent interference with the proper operation of the machine.

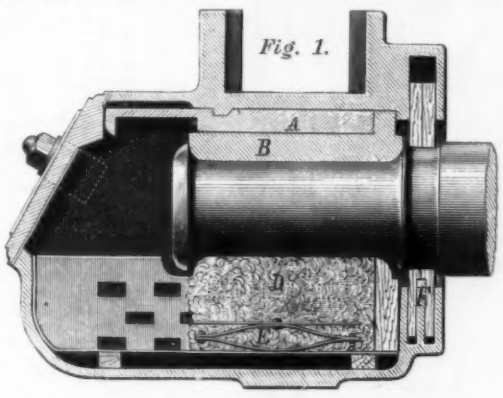


Fig. 1.

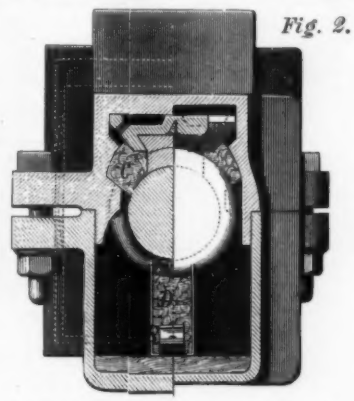


Fig. 2.

Lubrication, by the interposition of some material, either solid, liquid, or partaking of the nature of both, between the rubbing surfaces, or the substitution of rolling for rubbing friction, are the only means we have of reducing this evolution of heat and consequent waste of energy. The latter for mechanical reasons is practicable only in a very few special cases, so that for all general purposes an effective and economical means of lubrication becomes a most important factor in practical and operative mechanics.

Aside from the lubricating qualities of the different unguents used, the most effective and economical introduction of a given lubricant to and between the rubbing surfaces is a great necessity. In machines where the pressure between the surfaces is considerable, as in railroad car axles,

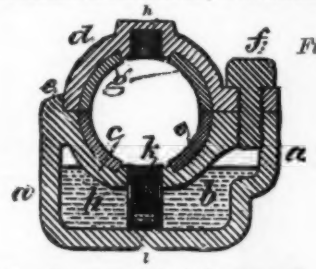


Fig. 3.

shafting where heavy or tight belts are used, and many others in which such pressures are inseparable from the conditions of the machine, the introduction and maintenance of a film of lubricant becomes difficult in proportion as the pressure is great; and wherever this fails of accomplishment, increased evolution of heat, waste of energy and rapid destruction of the parts are the result.

The loss of energy, which is the equivalent of the heat evolved, is always considerable, but is not generally noticed so long as this heat is conducted or radiated away with sufficient rapidity to prevent the parts reaching a temperature at which the lubricant itself becomes destroyed, as such, and the more seriously destructive effects upon the rubbing surfaces ensue.

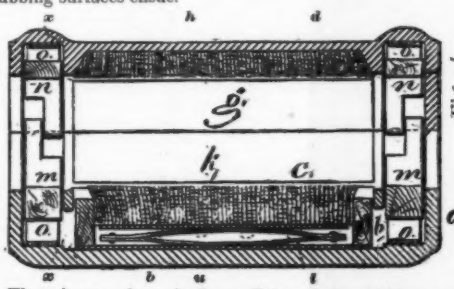


Fig. 4.

There is scarcely a single condition of the rubbing of surfaces, as in the bearings and journals of machinery, in which the integrity of the parts does not depend upon the rapidity with which the heat evolved is conducted away and dispersed; for in any case whatever, even with the most perfect lubrication possible, some heat is produced, and unless it be carried off as fast as it appears, the journal or bearing ultimately reaches a temperature at which its destruction or disintegration commences.

In a large proportion of machinery under the best methods of lubrication the heat is not carried off as fast as produced until a temperature is reached at which some of the best lubricants become deteriorated and lose the best part of their lubricating qualities, and rapid wear of the parts is the consequence. It is plain, therefore, that the method which shall so far insure a supply of the given lubricant to or between the rubbing surfaces as to keep the temperature of a running journal at a minimum will be in all respects the best, providing the lubricating material is not wasted in the operation of it. There are many excellent devices which subserve the purpose of keeping a good supply of the lubricating material in contact with the rubbing surfaces, but in most cases, and especially where the duty of the journal is a severe one, this is effected at a cost of considerable waste of the lubricant.

There are few, if any, more severely tried journals than those of railroad car axles, and the successful lubrication of these, economically done, has long been a desideratum. In many instances, of course, the heating and abrasion of a railroad or other journal is due either to defects in the proportioning of it to its work or to imperfections in the material; but, even under such abnormal conditions, the more perfectly they are lubricated the better will be their performance.

The system of lubrication which is the subject of this paper, as embodied in the several forms described hereafter, possesses features at once novel and effective, and their careful examination will well repay any one interested in this subject. Although quite new, it has been subjected to extended and exhaustive tests, in which it has acquitted itself in so admirable a manner that engineers cannot fail to become interested in it; and its record thus far will insure for it something more than mere investigation and trial on the part of the engineering profession.

Figs. 1 and 2 are respectively a longitudinal and transverse vertical section of a car axle-box as constructed on this principle. The particular features wherein it differs from others are as follows: A is an improved iron "keep," fitted to the box in such a manner as to secure the brass bearing, B, in place, while it admits of the latter being easily removed when required. The brass bearing, B, forms a kind of dovetailed joint with the "keep," as shown in the left-hand half section of Fig. 2. The principal object of this arrangement is to save much of the superfluous metal usually employed in holding the brasses, and which can never be utilized as surface bearing. Another of its principal features are the "stuffing-boxes," shown at C, Fig. 2, on either side of the brass bearing. These are cast in the top part of the box, and receive each a pad of felt extending the whole length of the journal. These pads are always thoroughly saturated with oil as collected by their capillary action from the surplus carried up by the surface of the journal, and are therefore always in condition to deliver up a portion of this surplus—no matter which way the journal may be turning—whenever from any increased speed, unusual pressure, or any abnormal condition the journal may demand an immediate increase of the amount of lubricant delivered to the journal surface, standing like sentinels at the very entrance for the lubricant between the surfaces, absorbing it when an unnecessary quantity is carried up by the journal, and storing it up ready for delivery at a moment's notice when required. The form of these "stuffing-boxes" is such that no cushion plate or other appliance is required to support or keep the felt pads in place.

A lubricating box, D, is placed in the oil reservoir of the box, partitioned therefrom by plate metal walls, in which apertures are made for the inflow of the oil, as shown in Fig. 1. This box is also filled with a thick pad of felt, which is kept in contact with the under side of the journal surface by the spring and plate, E.

One of the greatest difficulties heretofore encountered with the many devices for supplying a liberal amount of lubricant to car axle and other boxes has been to prevent the overflow and consequent waste of oil, as well as to thoroughly exclude all dirt, dust, and grit from the box and journal. In this system the device shown at F, Fig. 1, seems to be an admirable contrivance, and the record of wastage on long-continued runs establishes conclusively that it subserves the purpose intended in the most perfect manner. In the groove shown cast in the box is fitted a double washer, F, Fig. 1, the lower parts of which embrace a central tongue of iron projecting upward to *above the level of the outer flanges*. The two parts of this washer are caused to fit closely to the journal or axle by a small steel spring not seen, affixed to the outer edge of each half of the washer, forcing the two parts together. There is also a slight clearance at the lap joint of the washer to permit of the wear upon them being taken up by the spring. As the edges of the washers are, however, always well lubricated by virtue of the office they subserve in preventing overflow, and the pressure upon them very slight, their wear by the journal or axle is very small. Besides preventing the overflow and waste of oil by centrifugal action and entrance of dust and grit, this washer also prevents the entrance of drifting rain at the wheel end of the axle-box and the overflow of oil from its displacement by the heavier water accumulating in the bottom of the reservoir.

The application of the same system to shafting-boxes is shown in Figs. 3, 4, 5 and 6, in which Fig. 3 is a transverse section through one of the bolts which secures the cap, Fig. 4 a longitudinal vertical section, Fig. 5 a plan of the lower half of the box, and Fig. 6 a transverse section through *x*, *x*, Fig. 4.

In this case the felt pads are two in number, one, N, placed in a recess cast in the cap, and the other, K, contained between two thin perforated metal plates in the oil reservoir, *b*, at the bottom, both extending through the whole length of the journal or box proper. At the ends are formed recesses for the reception of wooden cut off pieces, *m* and *n* (corresponding to the double washer in the car axle-box), the upper and lower halves overlapping each other and held in contact with the journal by springs, *o*. The lower pad is pressed upward against the journal by the spring, *l*. The bolts, *f*, which secure the cap, *a*, pass through the casting into the oil reservoir as shown in Fig. 3, and by the removal of one of them a convenient means is offered of filling the reservoir without removing the cap. The whole is a very simple and cheap construction, strong and not in the least liable to get out of order or adjustment.

In this construction it will be seen that it is not required of the oil to find its way along the journal from some localized point of supply as with most self oiling contrivances; but the journal is continuously coated through its whole length with a film of lubricant by the lower pad of felt, while the upper pad serves to still further distribute the oil evenly over the surface, before it shall again come in contact with the lower half of the box, and before again meeting the lower pad.

It appears quite evident that with this construction there can be but one condition to prevent perfect lubrication, viz., so great a pressure between the surfaces as to exclude the lubricant, and under such conditions no system in which a liquid or semi-liquid lubricant may be used could possibly be successful.

The system of lubrication above described may be adapted to almost any form of bearing, and may be varied in design indefinitely to suit special forms of machinery; and it is already in use upon saw mandrels—another quite severe character of journal, and one quite difficult to lubricate properly—and many others unnecessary to specify, and in all cases with marked success.

Axle-boxes on this system have received a thorough trial on the Bombay, Baroda and Central India Railway, and gave the greatest satisfaction, as testified to by the Locomotive and Carriage Superintendent and other officers of the road. In one case two boxes filled each with *three pints* of oil, were run four months, and during this time 35,498 miles, without a single heating; and at the end of that time one box contained 2½ and the other slightly over 2¼ pints of oil, free from dirt and grit. The boxes were strapped and locked during the whole of this time and received no attention whatever.

On another occasion they ran nine months continuously, making 55,000 miles, starting with three pints to the box, and having remaining in each box, at the expiration of the nine months' run, one pint of oil.

They have been adopted by the government of the East Indies, who control the railroads in that country, and are now doing first class service on the Great Northern, the Midland Counties, the London, Brighton and South Coast, the North London, and other railways in England.

In a competitive trial with Blackburne's patent axle-box, there being two boxes of each patent upon the same car, each bearing being of the same quality of brass, using the same quantity of oil, and the trial being made to test the mileage, etc., of each system, doing exactly the same service and having the same amount of care and attention, the following results were had:

BLACKBURNE.

End wear of bearing	3/8"
Vertical wear of bearing	1/8"
Weight lost in ounces	13¼
Average miles for 1/64" vertical wear	7411·875
Average miles for each ounce of metal worn away	6712·641

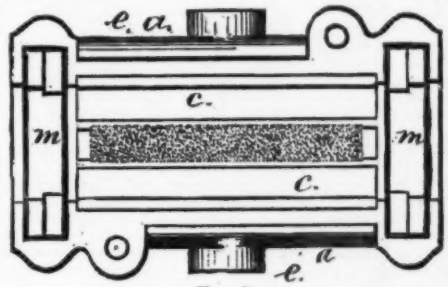


Fig. 5.

TOMLINSON.

End wear of bearing	1/16"
Vertical wear of bearing	1/64"
Weight lost in ounces	4⅛
Average miles for 1/64" vertical wear	22,235·625
Average miles for each ounce of metal worn away	21,561·818

The whole distance run in this case was nearly 89,000 miles, and the time nearly nine months; journals 3½" diameter and 9" long.

The admirable performance of this system as applied to shafting hanger boxes is quite as well attested, and as a specimen the following case may be adduced: They were fitted to a 2 in. counter shaft in the office of the *Brooklyn Daily Times*, on June 6, 1877, running at 200 revolutions

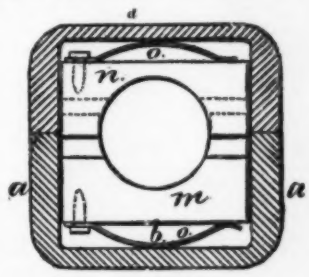
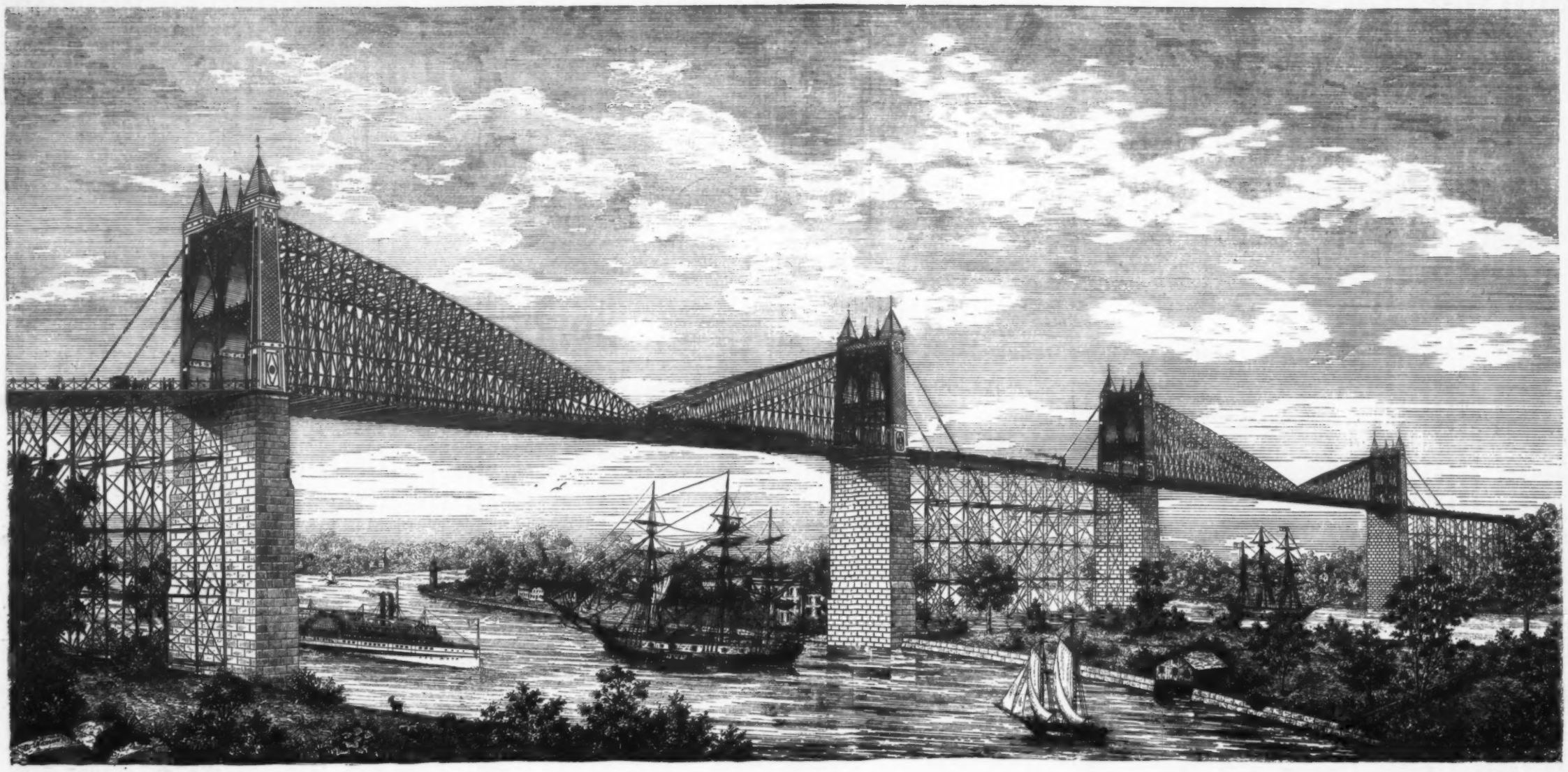


Fig. 6.

per minute, placing in the box 2¼ ozs. of oil. It was not touched for over six months or any addition of oil made during that time, and the shaft ran at all times cool, and without any attention whatever. In another large establishment in this city it has been in operation upward of six months, with similar results, and there is every indication that another half year will elapse before renewal of the lubricant will be required. Trial boxes have been run on one of the horse cars of the Third Avenue line in this city for over seven months, and are still in operation. The boxes have been opened once during that time, and were found to require no addition of oil, and it is thought that they would have run fully a year as originally started. In this case some oil was put in at the time of examination, but not because the original quantity had become exhausted. The length of time this box will run without renewal of oil will evidently be proportioned to the capacity of the reservoir, and this may generally be made to suit the time the box may be desired to run without attention or renewal. These facts speak loudly in its favor, and leave little room to doubt that the system as a whole constitutes a valuable improvement in this very wide mechanical field.

The address of the inventor and proprietor is J. B. Tomlinson, care of G. L. Kelty, 80 and 82 White street, New York.

J. T. H.



NEW YORK SIDE. BLACKWELL'S ISLAND. LONG ISLAND SIDE.

TRUSSED WIRE-ROPE SUSPENSION BRIDGE.

	West Channel.	East Channel.
From center to center of piers..	778 ft.	662 ft.
In the clear.....	734 "	618 "

New York Approach, Trestle Work..... 3580 ft.
Blackwell's Island, " " ..... 680 "
Long Island Approach, " " ..... 3900 "
Total length of the structure..... .....10532 "

THE NEW YORK AND LONG ISLAND BRIDGE OVER EAST RIVER, AT BLACKWELL'S ISLAND.—PLAN PROPOSED BY NEW YORK BRIDGE CO.

DESIGNED BY WALTER J. MORRIS, CIVIL ENGINEER.

Height in clear above high water, at center of bridge. 137½ ft.
" " " at piers.... .....130 "
Total height of towers above high water.....230 " "
Total width of bridge for two railway tracks, two carriage roads and two footpaths, 66 ft., 4 in.
Factor of safety for moving load.... 8
" " " dead load..... ..3
Average moving load per lineal foot..... .....4990 lbs.
For floor system moving load per lineal foot.....12750 "

THE PROPOSED NEW BRIDGE OVER THE EAST RIVER BETWEEN NEW YORK AND BROOKLYN.

THE design on page 1876 represents the plan proposed by the New York Bridge Company for the great railway bridge and iron trestle structure from the city of New York, at Seventy-seventh street, over Blackwell's Island to Long Island and Brooklyn, spanning the two channels of the East River at that point, the west channel span being 734 feet in the clear at the base of the piers, and 778 feet between center bearings, and the east channel 618 feet at base of piers, and 642 feet between center bearings. The height of each span at the center is 137½ feet above high water, and at the piers 130 feet, the approach to the west span on the New York side being an iron trestle work, commencing at the west channel shore, passing across the blocks to Lexington avenue, a distance of 3,500 feet, thence under Lexington avenue to Fourth avenue, connecting by Harlem Railroad with the Forty-second street depot. Each avenue is crossed by a Whipple truss bridge of 100 feet span.

The two bridges across the channels are connected by an iron trestle work, 680 feet long, over Blackwell's Island.

The Long Island approach is similar in construction to the New York side, in length 3,900 feet, and from thence connected with the entire system of railroads of Long Island.

These communications cannot fail to be of great benefit to our city, and the New York and Long Island Bridge, being a connecting railway link, must be of great value to its shareholders and those of the immediately joining railway companies. And eventually, when this bridge is connected with the Harlem and New Haven Railway, and that railway connected with the Broadway Underground road, and the latter with the railway tunnel now being constructed under the North River, connecting this city with Jersey City, by these connections there will be direct and complete railway connection from Brooklyn and most of the towns on Long Island with the lower and upper part of this city, and thence by unbroken rail to all sections of the United States.

This system of construction is known as a rigid or trussed suspension bridge. The new and valuable *improvements* claimed for this method of construction consist in the using of wire cables, hinged at the center of the span, and arch trusses on top of the cables, from the hinge to the towers; also the two rigid floor systems, from the center or hinge back to but not abutting actually against the piers, swinging close to the piers, but clear of them, and connected therewith by a freely sliding joint. These floor systems are suspended and braced to the cable, thus forming a rigid *structure* from the floor to the top chord of the top trussing above the cable. During expansion and contraction of the structure while under changes of temperature the hinge at the center rises about 11 inches above and falls about 11 inches below a given point in a vertical line. The two floor systems, or the floor of each half span, are connected by a freely moving sliding joint, from 4 to 6 feet under the hinge. Therefore the entire structure will move to and from the center under the extreme changes of temperature, the side trussing and floor system immediately at the towers passing back freely into the towers, only receiving sufficient side support to prevent any lateral movement from wind strains; the cables moving over saddles on rollers upon the top of the tower, thus allowing the entire suspended structure, from anchorage to anchorage, to move entirely free from any strains coming on any parts or members from expansion and contraction, and all the parts throughout being in harmony one with the other; and there can be no question as to the resulting strains, as desired, coming upon each member.

By this system of construction it is claimed that longer spans, say from 600 to 1,200 feet, with less material and greater strength and rigidity, can be obtained at a less price for the heaviest railway traffic than by any other method, and that the cost of erection is very much less, and at no time during construction will interfere with navigation.

A wire cable, either of steel or iron, is a form of material which gives the greatest amount of strength and elasticity. It is intended to use steel wire for the cables for the proposed bridge, the ultimate strength *exceeding* 160,000 pounds per square inch of metallic cross section, these cables sustaining the entire live and dead load of the bridge, and by using steel wire cables instead of iron links, as have heretofore been used in suspension bridges somewhat similar to this, there is a saving of ¼ metal in dead weight, with a gain of between 18 and 20 per cent. greater strength in practice, as the safety of a bridge structure is really in proportion to the limits of elasticity of the metal which is used, and in this case the elastic limit of the steel wire being more than $\frac{50}{100}$ of its breaking weight, whereas the iron links or iron wire does not exceed $\frac{10}{100}$ of its breaking weight. In the actual construction of this proposed work there will be four steel wire cables for each bridge. For the west or main channel each of the cables would be 1,680 feet long from anchorage to anchorage, each cable 13 inches in diameter, the piers 130 feet above the water, and the towers—at the saddle—90 feet above the piers, the total height of the towers above the water being about 230 feet.

The cables and suspenders for the floor of the railway are the immediately important members, and are subjected only to a tensile strain, and the stiffening members are under compression and compound strains—are only used to prevent continual vibration, but are of no immediate importance for the safety of the structure.

At the time of submitting plans and bidding for this proposed work this plan was the least in cost of any presented by several hundred thousand dollars. This iron structure would be the longest and the channel spans for their respective lengths constructed to sustain the heaviest traffic per lineal foot of any bridge work at present known.

This plan was designed by Mr. Walter J. Morris, Civil Engineer, associated with Mr. John D. Hutchinson and Mr. James Whipple Shipman, of the New York Bridge Company, No. 110 Broadway.

FLOATING BRIDGE OVER THE RIVER HOOGHLY.

AT a recent meeting of the Institution of Civil Engineers, London, the paper read was on "The Hooghly Floating Bridge," by Mr. Bradford Leslie, M. Inst. C. E.

This bridge connected Calcutta on the left with Howrah on the right bank of the Hooghly, at a short distance north of the East Indian Railway terminus. Various projects had been from time to time proposed, but ultimately the preference was given to a floating bridge, as it could be more cheaply and expeditiously constructed than a fixed bridge. The design was prepared in 1868, when it was intended to be carried out by a joint stock company, but after much delay, in 1872 it was undertaken through the agency of the local government of Bengal. The work was commenced in January, 1873, and the bridge was opened for traffic in October, 1874.

The present structure was the first and up to this date the only one of its kind affording headway for river navigation. It divided the port into two sections. The lower part was occupied by sea-going ships and steamers, and the upper part by inland craft and a few coasting vessels. As, however, the graving docks were above the bridge, it was necessary that an opening should be provided for the passage of shipping. The extreme rise and fall of the tide during floods was 20 feet, and at certain seasons there was a tidal wave 6 feet in height. The maximum velocity of the stream was 6 miles an hour. The depth of the river at the site of the bridge was variable, the greatest depth at low water being 6 fathoms.

The bridge was 1,530 feet long between the abutments, and the roadway was 48 feet wide, with foothpaths each 7 feet in width on both sides, so that the total width of the platform was 62 feet. There were four main longitudinal wrought iron girders at intervals of 16 feet in the width of the roadway, raised by timber trusses, resting upon pontoons, to a convenient height above the water for accommodating the boat navigation. The platform of the bridge was level for a distance of 384 feet on each side of the center, at a height of 27 feet above the water. Thence it fell by inclines of 1 in 40 to a distance of 584 feet on each side of the center line, where there was a length of 20 feet of level platform 22 feet above the water. Between these points and the abutments were the adjusting ways, the shore ends of which were 32 feet above low water. The approach on the adjusting ways was by a descent of 1 in 16 at extreme low water, and by a corresponding ascent at extreme high water; but at ordinary times it was either level or only slightly inclined. The platforms of the adjusting ways were supported on the lower flanges by three bow-string girders, the roadway being divided into two by the center girder. The footpaths were carried on cantilevers riveted to the outer girders. The bow-string girders weighed 66 tons each. They were 160 feet long between the end pins on which they were hinged, and had the usual trough-shaped upper and lower members. The shore ends of the bow-string girders were suspended on links, which was preferable to carrying them on rollers, even for fixed bridges, as being less likely to get out of adjustment, and tending always to restore the girders to their normal position at their mean temperature. The outer floating ends were hinged to pivot bearings, in order to admit of a slight drift up and down stream.

The floating portion of the bridge was carried on twenty-eight pontoons, coupled together in pairs to secure stability. With the exception of the two pairs in the center, which supported the movable sections of the bridge, each pair carried 100 feet in length of the platform. Each pair was coupled together, at a maximum distance of 41 feet from center to center, by four timber sills, bolted to the decks of the pontoons at intervals of 16 feet. These sills constituted the bottom members of the four main longitudinal trusses, the top members being the wrought iron girders carrying the roadway. With the exception of the upper girders, the whole of these trusses were of teak. The coupled pontoons were further connected by strong horizontal diagonal bracing of bar iron. The timber sills and the bracing being only 4 feet above the water, the space between the coupled pontoons was not available for navigation, and floating fenders or booms were provided to divert boats from these openings. Ordinarily the main girders overhung the pontoons 21 feet, their ends being supported by the inclined struts of the trusses, leaving a width for navigation of 42 feet, partially obstructed by the raking struts. For the convenience of the country craft, there were two rectangular openings of 60 feet clear span between the fourth and the fifth pairs of pontoons, reckoning from each abutment. The roadway over these openings was carried on eight girders, each 2¾ feet deep, and weighing 8 tons. They rested on saddles secured to the top of the cross-bearing girders, which were suspended to the ends of the ordinary main truss girders. All the pontoons were 160 feet long by 10 feet beam, with holds varying from 8 to 11 feet in depth, according to the dead weight to be carried. Each pontoon, excepting those of the movable sections, was accurately anchored by permanent moorings, laid exactly in line with the center of the pontoon, the distance between the up and the down stream anchors being 900 feet. The strain on the chain cables varied from 5 to 25 tons; their great length afforded the necessary "spring," to allow for the rise and fall of the tide, but a few links were taken in during the dry season, and slacked out again during the flood season.

The 200 feet opening for the passage of ships was one of the most difficult problems in designing the bridge. Owing to the strength and irregular set of the stream and eddies, ships could only be moved at or near slack tide; and it was a rule that all vessels of more than 200 tons must be moved by steam against the tide. The bridge was generally opened twice a week at high water, but occasionally at low water. The opening was effected by removing the two center sections of the bridge bodily. These sections were connected with the fixed portions of the bridge by drawbridges, which, on being run back, left a clearance of 20 feet on each side of the platform of the movable sections. By means of steel warps, laid to buoys moored for the purpose, these sections were warped up stream far enough to clear the rest of the bridge. They were then disconnected and sheered over, one on each side, leaving a fair way clear of all obstructions. The bridge was closed by reversing these proceedings. The ordinary time taken in opening the bridge was fifteen minutes, and in closing it twenty minutes.

There was a daily traffic of about 6,000 tons of heavy goods, which were conveyed in bullock carts, besides foot and carriage passengers. The ironwork of the pontoons weighed 1,650 tons, that of the girders 875 tons. The whole of this, as well as the mooring chains, was sent from England, and was erected and riveted up in Calcutta. The teak timber, which weighed 1,500 tons, was procured from Burmah.

The different parts of the structure were minutely described. An account was also given of the operations connected with the laying of the forty-eight permanent moorings, with the fitting of the truss work, with the hoisting into position of the sixteen 60 feet girders, and with the erection and launching of the 160 feet bow-string girders. The particulars were likewise recorded of an accident that delayed the completion of the work about three months. This arose from a deeply-laden ship fouling two vessels, which parted from their moorings, and both were sent up stream on the top of the "bore" at the rate of five knots an hour. One vessel went through the center opening, but the other struck the bridge, causing three pontoons to be sunk and the superstructure to be completely wrecked.

OVER 386 tons of steel rails have been rolled in 24 hours at Brown, Bayley & Dixon's Works, Sheffield, Eng.

OFFICIAL INSPECTION AND TEST OF THE GREAT TAY BRIDGE.

THE official inspection of the Tay Bridge lately took place, that very responsible duty being performed by Major-General Hutchison, Inspector of Railways for Scotland. So says *Engineering*. It was continued for three days.

The inspector was met on his arrival in Dundee, shortly after ten o'clock in the morning, by ex-Provost Cox, Chairman of the Tay Bridge Company, and by Mr. Bouch, C. E. Previously six of the largest locomotives were run across the bridge from the south side of the Tay as a sort of preliminary test. On the engines there were Mr. John Waddell, contractor; Mr. Allan Stewart, C. E.; Mr. Holmes, locomotive department, Cowlairs; and Mr. Simmons, local traffic superintendent, all of the North British Railway.

The inspection commenced on the 245 ft. spans, the six engines being placed on each span successively, their aggregate length being almost equal to the full length of the span. There was no perceptible deflection on the girders with the exceptionally heavy load thus brought to bear upon them. By two o'clock p.m. all the large spans were completely tested, and shortly afterward the inspection of the smaller spans was commenced and continued till late in the afternoon, with the same satisfactory results. General Hutchison expressed his satisfaction with all he saw. On the following day the work of inspection was continued, and on the day after General Hutchison gave to the piers and the substructure generally a similar careful examination to that which he gave to the superstructure. He sailed across the river, inspecting the piers, in order to ascertain if any damage had been done by his operations on the preceding days.

Speaking of the official inspection by General Hutchison, Mr. Bouch, the engineer of this important work, remarks that the object of the examination and test should be borne in mind. It was to ascertain, beyond every possible doubt, that the work, in design, material, and execution, is equal to its requirements, making the security of the public, as far as these three essentials are concerned, an absolute certainty. The inspector made this test with six of the largest and heaviest engines which have yet been built—each engine and tender weighing 72 tons, and covering a length of 48 ft. 6 ins. from the extreme points at which the load bears on the rails. It is obvious, therefore, that with five of these engines, coupled or placed close together, a weight of 360 tons was distributed over one of the largest spans, 245 ft. in length. This load was first placed on the girder as a dead load, and then as a moving quantity—the utmost deflection or bending being only 1¾ in. He proceeds to say that when it is considered that one of these spans can only carry at one time twelve mineral wagons, each weighing a gross weight of 13½ tons, giving a total of 162 tons, it will be evident that the test load, which was put on with such a satisfactory result, was more than double the greatest possible working load which can ever come on the bridge. Again, as regards the passenger traffic, the comparison is even more assuring. Eight ordinary carriages are all that can be on one of the large spans at one time; and if these are all filled with people—say 50 in each—the total weight will only amount to 109 tons, or less than one-third of the testing weight. But the Tay Bridge itself is unprecedented in its character, and so the two things are fitting. The result, however, is the complete establishment of this fact—so important to the public—that the bridge is strong out of all proportion to its possible necessities. As a matter of fact, the load which the structure is calculated to carry is six times greater than that which it was subjected to by General Hutchison. The smaller spans yielded results quite as satisfactory as the large ones, and such a verification of the integrity of a work so important and novel in its great engineering features, so bold in its enterprise, and of such vast significance as a commercial fact, must be a source of pleasure and gratification to the whole engineering world, quite as great indeed as it is to the public of Dundee, and to those whose skill and energy have brought it to completion.

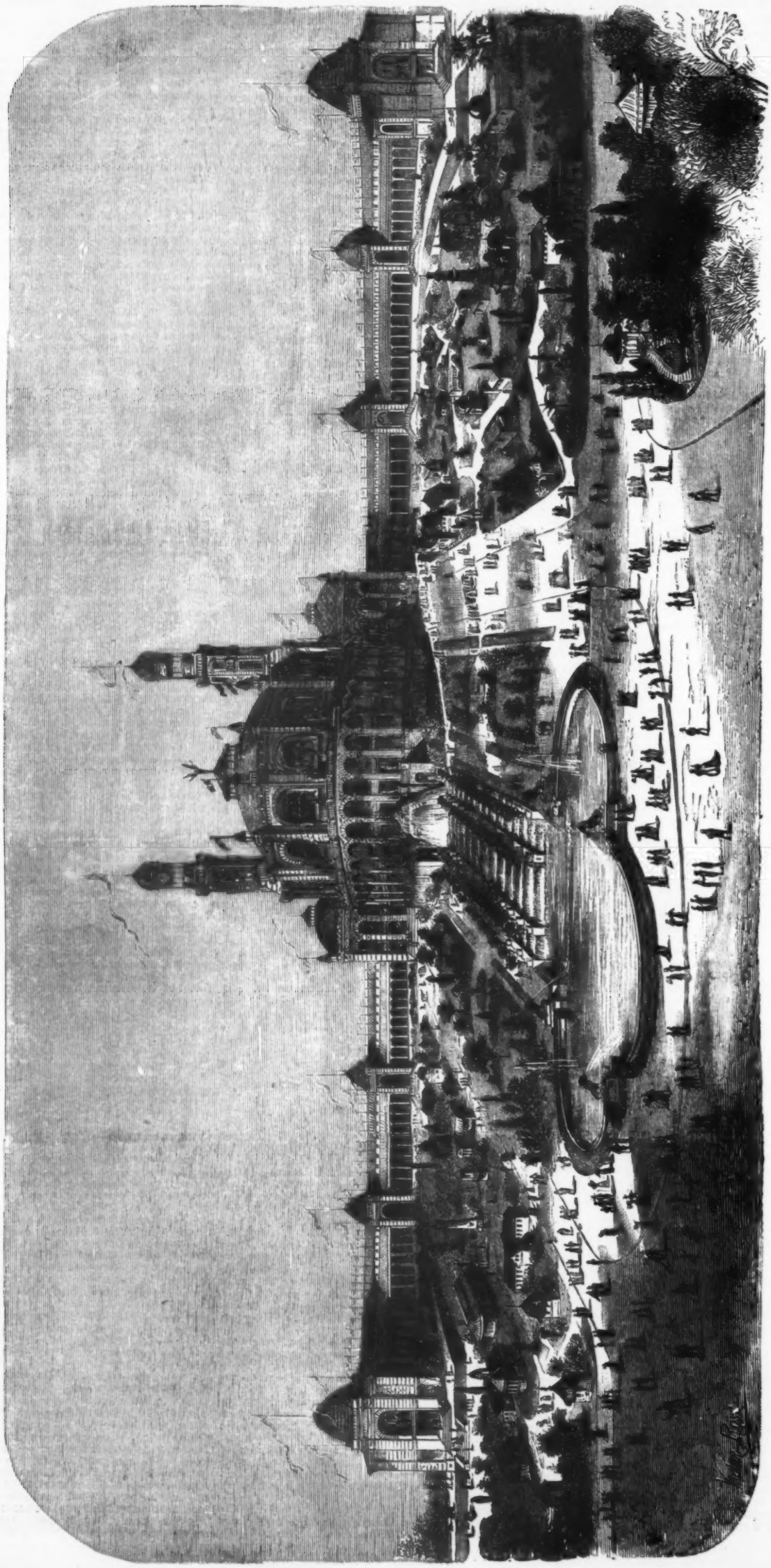
The Tay Bridge is the longest structure of its kind spanning a running stream. It is nearly two miles in length, or 10,321 feet, and its construction has involved the higest engineering and mechanical skill.

Drawings and particulars of the construction may be found in SUPPLEMENT No. 66.

GERMAN COAL MINING.—The production of coal in the Saarbruck district in 1877 was 4,403,958 tons, against 4,450,607 tons in 1876, and 4,473,206 tons in 1875. The production thus declined in the course of the last two years to the extent of about 70,000 tons. On the other hand, the production of the Ruhr basin has considerably increased since 1875.

GOLD DISCOVERIES IN NEW GUINEA.

RECENT important gold discoveries have been made in New Guinea. The well-known missionary, Rev. W. Lawes, from New Guinea, has arrived in Sydney, and gives an interesting account of the success he met with among the natives. They appeared to have received Mr. Lawes in a most friendly manner, and he was enabled to visit, in company with Mr. Goldie (a naturalist who is collecting plants and specimens), about 30 villages never before visited by white men. The finding of gold in New Guinea is, however, the most interesting of Mr. Lawes' intelligence. Gold has, of course, always been believed to exist there, but the field and the quality have never before been ascertained. The following is the account given by Mr. Lawes: "Gold has been discovered in the interior of New Guinea. Mr. Goldie and I about two months ago went inland, and on that occasion one of his party, a New Caledonian, got some gold-bearing quartz of a fine and rich quality. They afterward prosecuted a search, and obtained several other specimens, and also a quantity of alluvial gold in the sand of a river bed. I have seen all these, and have specimens of each in my possession. The gold found in the sand is very fine." Mr. Goldie's agents in Sydney will have samples of each assayed, and the results are to be made known. The existence of gold in New Guinea, says Mr. Lawes, may be considered proved beyond all doubt. He continues: "Mr. Goldie is not prosecuting his search in this direction any further, but has left the district for the present to visit a place further south. It is quite true that an organized party of competent men visited New Guinea to prove what the mineral wealth of this new and truly great country really is. But nothing can be done until after the wet season." The specimens shown Mr. Lawes are pronounced very fine indeed. The excitement in Sydney upon the receipt of this important news was very great.



THE GREAT EXHIBITION AT PARIS, 1878. VIEW WITHIN THE GROUNDS, SHOWING THE GRAND FOUNTAIN AND THE PALACE OF THE TROCADERO.

THE PARIS EXHIBITION OF 1878.

IN previous numbers of the SUPPLEMENT will be found the general history of the Exhibition and several interesting plans and views. We now present a picture of the Palace of the Trocadero, which forms the main entrance to the Exhibition grounds and buildings. This is a permanent building of stone, of imposing appearance and large dimensions. It contains a hall capable of holding six or seven thousand persons. Here the formalities of opening the Exhibition, award of prizes, etc., are to be conducted. The building is about 275 feet long and 230 feet broad. Temporary wings in circular form have been extended on each side, forming galleries for exhibition purposes. These wings are each about 1,360 feet long and 40 feet wide. On entering the Trocadero and passing through into the grounds a magnificent sight is presented to the eye of the visitor. A beautiful fountain is arranged at the rear of the Palace which pours its waters down a series of cascades adorned with ornamental shrubs and flowers. Artistic pathways lead in all directions, and curious buildings containing rare and costly objects of interest are everywhere encountered. The general aspect of the grounds and surroundings is extremely interesting and picturesque. Proceeding down the slope of the grounds the visitor comes to a spacious bridge not here shown that crosses the River Seine, on the opposite side of which stand the enormous structures that constitute the principal part of the Exhibition.

THE TECHNOLOGY OF THE PAPER TRADE.*

By WILLIAM ARNOT, F. C. S., Edinburgh.

LECTURE V.

The chemicals used in the paper mill; their nature, economical use, and methods of valuation. The recovery and re-use of soda as an economical process, and in its sanitary bearings. The disposal of washing and machine waters, so as to minimize the pollution of streams.

ALMOST as important as the introduction of machinery has been the application of chemicals in the manufacture of paper. We have already seen what important parts soda and chlorine and alumina play in the various stages of the process, and now it falls to us to consider the nature of the commercial chemicals containing these active agents.

First in point of time, if not also in importance, we have caustic soda. This agent, as now used, was unknown as a commercial article until little more than a quarter of a century ago. It is now manufactured in very large quantities, and is used extensively in soap-making, bleaching, paper-making, and—in smaller proportions—in many other trades. We shall first look at the chemical structure of this substance, and of the salts formed by its union with carbonic acid, which are also useful to the paper-maker. Then we shall glance, in succession, at the commercial methods of producing these agents; at their employment in the paper mill; the methods of testing or valuing them; and the methods of recovering them after they have done their work, and of re-using them in the mill.

Caustic soda consists essentially of the metal sodium combined with oxygen and hydrogen. When sodium is burned in oxygen gas, two equivalents of the metal combine with one of the gas, and sodium oxide (Na_2O) is the result. This substance has a powerful affinity for water, with which it combines, forming sodium hydrate (NaHO). The reaction may be symbolized thus:—$Na_2O + H_2O = 2NaHO$. This agent, contaminated with varying proportions of soda and other salts, is known in the arts as "caustic," or caustic soda. As its name implies, it is highly caustic, or burning in its nature. It is so very deliquescent that, if left exposed in the air for some little time, it will become liquefied by the water it absorbs.

For all substances of an acid nature caustic soda has a strong affinity, and it is in virtue of this property that it is so eminently serviceable in the treatment of raw fiber-yielding vegetable substances. When exposed to the air it not only absorbs moisture, as already stated, but also carbonic acid, carbonate of soda being the result. The exact composition of this substance in the anhydrous condition is Na_2CO_3. When this is formed from sodium hydrate, a molecule of water is involved in the reaction, thus—$2NaHO + CO_2 = Na_2CO_3 + H_2O$. Soda ash and soda crystals consist essentially of carbonate of soda, the former being anhydrous and the latter combined with seven equivalents of water of crystallization. The soda recovered by incineration from the waste soda lyes is also a carbonate, indeed a crude soda ash often quite as rich in available soda as ordinary commercial ash. The impurities are, however, generally of a more objectionable nature.

Common salt is the native sodium compound upon which the chemical manufacturer operates to produce the numerous soda salts met with in commerce. Upon this he brings oil of vitriol or sulphuric acid to bear, with the result that it is split up into two, the chlorine going off with hydrogen as hydrochloric acid, which is in turn also split up, that the chlorine may be got to make bleaching powder. The sodium takes the place of the hydrogen which has been eliminated from the sulphuric acid, and thus becomes the basis of a new chemical structure known as sulphate of soda or salt-cake. This substance is of no value to the paper-maker, but it is the first step toward producing what is really wanted.

The salt-cake is mixed with limestone and carbon or small coal, and heated to fusion in a reverberatory furnace, the practical result being the production of soluble soda—partly caustic, partly carbonated—and insoluble sulphides of calcium. Lixiviation dissolves out the valuable soda products, leaving the insoluble calcium and sulphur compounds to be disposed of as best the manufacturer can, so as to minimize the nuisance which must necessarily result from their gradual decomposition and the formation of soluble sulphides.

The soda solution may either be evaporated, and the product furnaced into soda ash, or it may be treated with caustic lime, and the caustic liquor concentrated and finally kept in a state of fusion at a red heat, until the impurities are so reduced in quantity that the product may test 60 or 70 per cent. of real soda (sodium oxide), as may be required. What is known as caustic soda ash contains variable proportions of its soda in the caustic state, the bulk of it, however, being carbonated. Ordinary ash contains but little caustic, and the difference is produced by employing different methods of evaporating the crude liquor, and calcinating the product. Refined soda ash is just ordinary soda ash freed from color and certain impurities by resolution, clarification, and evaporation, or by the treating of the finest of the crude liquors with small proportions of nitrate of soda, to oxidize the sulphides. It is not necessarily, or, indeed, usually, stronger than ordinary ash. Freedom from color, sulphur, and mechanical impurities are its characteristics. When a hot saturated solution of refined soda ash is allowed to cool, nearly pure carbonate of soda crystallizes out, in combination with seven equivalents of water—the crystallized product being what is so well known as soda crystals.

The important part which caustic soda plays in the economy of the modern paper mill is now well understood. I have already adverted to its action upon grease, oils, gluten, resin, and silica, as well as upon cellulose itself, and need only further remark that while the agent is indispensable it is also expensive—amounting to about 10 per cent. of the value of the product—and this being so, it is important that it should be used in the most economical manner consistent with effective work. That there is in this respect room for improvement in very many mills there can be no doubt. I have seen much accomplished where the boiling arrangements had been previously considered perfect. It is sometimes found economical to purchase soda ash instead of caustic soda, dissolving it, and causticizing the solution with quick lime. When the waste lime sludge can be readily got rid of, it is possible to make a profit of this; but at most mills it is a serious matter to get rid of the sludge, as well as the other refuse matters which so rapidly accumulate. For size making, soda crystals are no doubt very suitable, being the purest form in which soda can be purchased commercially. From experiments made under my own direction, however, I am convinced that an equally good size can be made with soda ash, provided only it be quite free from color and mechanical impurities, and it should not be difficult to secure a supply meeting these conditions. The result of the use of ash as against crystals is a saving in the sizing charges.

Every paper-maker should know the strength of the chemicals he is using, and that not so much to satisfy himself as to the character of the goods which his merchants are sending to him—though this is not unimportant—but, what is of more consequence, that he may be enabled to regulate their use in the mill so as to insure uniform and satisfactory results. The determination of the soda in caustic, and in the various carbonated compounds, is one of the simplest of analytical processes. It would be a mistake, however, to suppose that even this simple operation can be done successfully and accurately without some manipulatory skill and suitable and accurate weights and measures. First of all we must prepare a standard solution of sulphuric acid of such a strength that the contents of each division of the burette intended to be used will equal one grain of real soda. By operating upon 100 grains of the sample to be tested with such a solution, the divisions consumed will give the percentage of soda direct. There is some trouble connected with the preparation of a solution of this description, and, unless the mill staff includes a trained chemist, it is better to secure a supply of accurately adjusted standard acid from a professional chemist. Professional jealousy need not prevent any analytical chemist supplying this, as the work to which it is to be applied is such as can only be done in the mill, if it is to be of the practical utility I have indicated.

In addition to the standard acid, a solution of litmus must be at hand, and in some cases it will be found advantageous to have a supply of litmus papers as well. With these tests prepared, the appliances required for the actual operation are few and simple. A balance and weights, the former capable of turning with one-tenth of a grain, a burette and stand—the burette graduated to indicate quarter per cents will be sufficient—a large porcelain basin, with a suitable tripod stand, and Bunsen burner, and a few glass stirring rods. Boiling water, from a clean kettle, will be quite suitable for dissolving the sample. The process may be conducted as follows:—The sample, which must, of course, be a fair representation of the drum or cask from which it is drawn, should, in the case of caustic soda, be quickly crushed into small fragments and returned to the stoppered bottle in which it was collected. There is no need for grinding up the sample, for, if time is occupied doing this, moisture will be absorbed and the results vitiated. The contents of each drum are usually pretty uniform, and the crushing recommended will give the operator a sample quite fit to work upon. Samples of soda ash and soda crystals will, of course, be fairly representative of the casks from which they are drawn. One hundred grains of the prepared sample must be weighed out upon a watch glass, or slip of glazed paper, and transferred to a porcelain basin, with at least half a pint of boiling water. The watch glass is preferable for caustic soda, and the weighing in the case of that agent must be done expeditiously. While the sample is dissolving, the burette will be charged with the standard acid. To the soda solution a few drops of solution of litmus sufficient to color it distinctly will be added. The acid will then be run into the blue soda liquor; at first and within reasonable limits this may be done rapidly, but toward the close of the operation the acid must be added cautiously and the solution kept well stirred. In the case of caustic, when the blue has distinctly changed into red the operation may be considered completed, and the measures consumed read off the burette; as I have already indicated, this is without calculation the result required. When the soda in the sample is a carbonate, the blue color of the litmus will be changed to pink before all the soda is neutralized, owing to a portion of the liberated carbonic acid remaining in solution; this must be eliminated by placing the basin over the Bunsen and boiling the solution. The blue color will thus be restored, and more acid must be added, repeating the boiling from time to time, until the red color becomes permanent. It is sometimes necessary to filter the soda solution before testing; this applies specially to recovered soda, and, although in a less degree, to soda ash.

In sampling soda, as in sampling everything else, great care must be taken to secure a fair average of the stock. Professional chemists, as well as buyers and sellers, are often much annoyed by the discrepancies in the results obtained on analyses, traceable alone to different samples having been supplied to the different analysts, under the assumption that they must be alike, while in reality they are often very different. This is especially the case with samples of recovered soda, and I cannot too strongly urge that in all cases where disputes are likely to arise between buyer and seller, samples should be most carefully drawn in duplicate, either mutually or by an independent competent party.

When soda has done its work in the process of boiling, the spent alkaline liquors are highly charged with matters which, when allowed to flow into streams, produce an effect which is very offensive. This has led to the evaporation of these liquors, and it is satisfactory to know that in most cases the operation has not only greatly increased the purity of the streams, but has also proved remunerative to the millowners. That the process may be conducted profitably or otherwise will depend upon the strength of the waste lye, the price of coal—taking quality into account—the efficiency of the apparatus employed, and the skill with which it is worked. There are many competitors in the field, each with the best recovery apparatus, occupying little or no room, costing little or nothing to erect, and recovering the soda in a high state of purity, at an infinitesimal cost, and, of course, free from the nuisance of smell. As I devote much attention to this branch of chemical engineering, I must be excused for not giving an opinion upon any of the competing systems. I will, instead, try to point out some of the features which a good recovery furnace should possess. It should be constructed of the very best fire-bricks, not too siliceous in their nature, and bound very strongly with iron plates and binders. The evaporating pans should be constructed of what are known as "best" plates, and the workmanship should be quite equal to that of a first-class steam boiler. Both upper and under sides should be exposed to the action of the hot gases as they pass onward from the furnace to the chimney. The structure, as a whole, should be neat and strong, well housed, and capable of being kept cleanly and worked easily. The furnace should be shallow, the fire bridge low, the hearth not too deep, the roof low, and the pans long and rather shallow. The draught should be capable of easy adjustment, and, in working, must be frequently altered. The quantity of soda recovered should be equal to from 70 to 75 per cent. of the soda used, and to secure this none of it must be drawn up the chimney, converted into slag, or run into the river. It should be possible to work the furnace with very little smell; but, in my travels, I have only seen one that completely prevented smell—a very expensive erection designed by a French engineer. It is an easy matter preventing smell in the recovery house, but the more objectionable smell from the chimney is not so readily overcome. All lyes having an average strength of 5° T. and upward should be evaporated at least without loss; below that strength it will require very good working to make both ends meet. That the boilings of most raw materials should be kept out of our rivers there can scarcely be two opinions. Not to speak of the offensive appearance which they are calculated to give the stream, both on account of their color and their frothing quality, the water must be rendered quite unfit for any of its primary purposes. I am far from being in favor of harsh measures, and quite realize the importance of fostering rather than oppressing our manufactures; but where it can be shown that a public good can be effected, not only without loss to the manufacturer, but as a positive gain, there is little reason why it should not be done. The paper-makers on the Esk, near Edinburgh, who were first driven to evaporate their liquors, had, no doubt, many difficulties to overcome; efficient apparatus was yet to be designed, and in some cases four entirely different sets of apparatus were erected before a reliable working system was obtained. This involved much loss, which no paper-maker resolving to recover his spent soda need now incur. Some of the earlier furnaces consumed as much as eight to ten tons of coal for every ton of soda recovered. Now, however, from one and a half to two tons should be sufficient to recover a ton of 48 per cent. ash from esparto liquors.

Before the soda is withdrawn from the furnace the organic matter should be well burned off, so that the product may not smell offensively when exposed to the air. It should then be deposited on the recovery house floor in such a way that the carbon will be readily burned out without fusing the mass. The product should be spongy, friable, and easily dissolved. It is always more profitable to causticize and use up the recovered soda in the mill where it is produced than to pack and sell it. The causticizing apparatus should, if possible, be so arranged as to avoid hoisting and pumping. It is seldom that the levels are such as to admit of both objects being attained, and in some cases neither of them are attainable. The agitating vessels should be capacious and well proportioned, provided with ample agitating and steaming power. A good size of pan is 6 ft. deep by 7 ft. in diameter, and capable of taking a charge of 12 to 14 cwts. of soda. The soda is sometimes, and with advantage, dissolved in a separate vessel, and the liquor, free from sedimentary matters, introduced into the causticizing pan. There is thus no risk of destroying the agitators with hard lumps of fused soda, or pieces of brick, which sometimes get into the soda heap. The lime required to causticize a ton of soda will vary from 9 to 15 cwts., depending upon its quality, the strength of the recovered soda, and whether it has been dissolved in clean water or coolings. It is scarcely possible to eliminate the carbonic acid entirely from solutions made with coolings, yet it is sometimes imperative that these be used for that purpose. The lime will, of course, be put into a cage hung over the side of the agitating vessel, and not into the vessel itself. From four to six hours' steaming and agitating should be sufficient to causticize the soda as thoroughly as the condition of the solution will allow. After from two to four hours' quiescence the clear caustic liquor will be run off, and the lime sediment agitated for half an hour or so, with a further quantity of water, and again allowed to settle. The weak soda solution thus obtained will be added to the original strong liquor, and the lime washed into draining vessels, the drainings being used for dissolving the next batch of soda. It is very difficult to remove the last portions of the soda from the lime sediment, and there is, of course, a limit to the amount of water that can be used for that purpose. By a process of washing in the drainers, analogous to the process of claying sugars, most of the remaining soda liquor can be driven out or displaced by clean water. The causticized soda liquor will be measured into the boilers, the value of each inch in depth of the measuring cistern having been previously ascertained. There is always a certain loss of soda to be made up with fresh caustic or with causticized soda ash liquor, and it is better to use the new and recovered together in some definite proportion in each boiler, rather than to boil so much of the raw material with all fresh and the remainder with all recovered soda. The strength of the recovered soda is thus kept uniform, and in every way better results are obtained.

The nature and valuation of bleaching powder must now receive our attention. The chemical composition of this substance is rather complex. If a sample of 35 per cent. powder be taken and agitated with water it will be found that about 85 per cent. has gone into solution, the remainder being insoluble. The soluble portion consists chiefly of hypochlorite of calcium represented by the formula $CaCl_2O_2$. This is the agent which, yielding up its chlorine, performs the very important function of bleaching the half-stuff prepared in the breaking engine. The remainder of the soluble matter is the inactive chloride of calcium, and some-

*A recent lecture delivered before the Society of Arts, London. Lecture I., Scientific American Supplement, No. 109. Lecture II., Supplement, No. 110. Lecture III., Supplement, No. 116. Lecture IV., Supplement, No. 117.

times also small quantities of chlorate of calcium. The insoluble portion consists of lime, 10 per cent.; carbonic acid, 4 per cent.; and silica, etc., 1 per cent.

I have already stated that the chlorine is held in very feeble union with the other elements of the hypochlorite; it may indeed be considered as an almost free agent, its action upon coloring matter being energetic, and the destruction of the color complete and permanent.

The destructive effect of the agent may readily extend to the fiber itself if too strong a solution or too much heat be employed. The temperature in hot bleaching should not exceed 90° F., or the cellulose will be sure to suffer in weight, color, and strength. The only physical feature of bleaching powder which it may be well to note is the readiness or otherwise with which the insoluble matters subside in the mixers, this being very much dependent upon the nature of the limestone or chalk used in the preparation of the powder.

The process by which bleaching powder is produced may be very briefly described. The lime, which is the basis of the structure, is simply calcined limestone or chalk slaked with a due proportion of water, and after thorough hydration screened or dressed so as to remove sand and other gritty impurities. This prepared lime, which is an impalpable powder, is spread upon the floor of a chamber constructed of stone or lead, to a depth of six inches or so. The gaseous chlorine, the preparation of which I will refer to immediately, is delivered into the chamber, and is absorbed by the lime, the result of the combination being bleaching powder ready for packing into casks. There is a limit to the power of lime to take up chlorine, and in practice it is found difficult to get that portion of it which is in a condition available for bleaching much above 35 per cent., and at that standard it is usually sold in this country.

The chlorine gas is now almost entirely generated by Mr. Weldon's patent process, the result of the extensive adoption of which has been to increase the production and reduce the cost of bleaching powder. It will be remembered that the hydrochloric acid, produced by the decomposition of common salt in the manufacture of soda, was stated to be the source of the chlorine used in producing bleaching powder. This acid is decomposed when brought into contact with black oxide of manganese, one-half of the chlorine being liberated in the gaseous condition, the other combining with the manganese to form chloride of manganese. It used to be customary to discharge this agent into our streams and water-courses as a useless product, and the result of doing so seriously interfered with the purity of the water. By a very beautiful process Mr. Weldon has succeeded in conferring a value upon this agent, which is the best guarantee of its being kept from again polluting our rivers. The spent manganese liquor is neutralized with limestone or chalk, and allowed to clarify, when it is discharged into a deep malleable iron vessel called the oxidizer, and into this a certain quantity of milk of lime, sufficient to precipitate all the manganese and one-third more, is pumped; a strong blast of air is then blown through the mixture until the precipitated red oxide is oxidized into black oxide, or rather, as Mr. Weldon calls it, manganate of manganese. When this effect has been produced the blast is stopped, and the contents of the oxidizer discharged into settling tanks, when the manganate subsides and chloride of calcium liquor comes to the top. The latter is run to waste, and the manganese mud, as it is called, is run into stone stills along with hydrochloric acid, when the same reaction as before takes place, and the same liquid is produced, to be treated again precisely as I have described. This round of changes goes on continually, small additions of fresh manganese being made from time to time, to compensate for the loss inevitable in this as in almost all manufacturing processes.

The valuation of bleaching powder involves more labor and manipulative skill than the testing of soda. The percentage of available chlorine is what has to be determined, and there are several methods of doing this; but two are generally in use, and I shall describe both of them. The reaction in both processes is an oxidizing one; in the one ferrous oxide is converted into ferric oxide, while in the other arsenite is converted into arsenate of soda. In the iron process, as it is called, 39·15 grains of pure sulphate of iron are dissolved in about four ounces of water and acidulated with a drop or two of dilute sulphuric acid. Two hundred grains of the sample to be tested are rubbed up with water in a large mortar, and the solution made up either to 10,000 grains or to a liter, according as English or French measures are being used. A burette graduated into thousandths and decimals thereof of the whole volume of the solution prepared is charged from the mortar with the aid of a porcelain ladle. From the burette the bleach liquor is delivered into the iron solution, contained in a vessel of about 12 ozs. capacity, until the iron is all changed into the ferric state. To ascertain precisely when this effect is produced, a little of the mixture is lifted on a glass stirring rod and dropped upon a solution of red prussiate of potash, which has been previously spotted over a white slab; on the two drops coming into contact, a blue or—as it approaches completion—green coloration will be the result so long as any of the iron exists in the ferrous state. When the iron is completely oxidized no such coloration will be produced. The iron used equals exactly five grains of chlorine, so that the calculation is a simple one. It is right to state that objection has been taken to this process, but I have not been able to discover wherein error is likely to arise in its execution more than in any other, unless at one point where a slight loss—and with care it need be but very slight—occurs, owing to the liberation of chlorine in the gaseous state toward the close of the operation, resulting from the iron solution being acid. To insure satisfactory results, that is, results within one-fifth per cent. of the truth, the following particulars must be attended to:—First. The iron must either be quite pure, or its value must be ascertained and allowed for. Second. The weights and measures must agree among themselves; it matters little whether either of them have a precise value, so long as the smaller weights and divisions are *aliquot* parts of the larger. Third. A drop or two of acid is sufficient to add to the iron solution; more must be avoided. Fourth. Care must be taken to insure the complete solution of the soluble part of the powder, and the sediment should be uniformly diffused through the liquor, by stirring with the ladle previous to charging the burette. Fifth. The burette should be filled, the level adjusted, and the testing started without loss of time, so that the sedimentary matter may not settle in the burette before the operation is completed; of course the iron solution will be ready and the slab spotted before the burette is charged. Sixth. While the bleach liquor is being run into the iron solution the latter should be kept well stirred, and toward the close of the operation the liquid should be run in in small, successive quantities, with frequent testing.

The arsenic process is conducted as follows:—A standard solution of arsenite of soda is prepared by dissolving 139·5 grains of pure arsenious anhydride and 400 grains of pure crystallized carbonate of soda in 6 or 8 ozs. of water. This can be best effected by boiling and shaking for some time; when the desired effect has been produced the solution is allowed to cool, and is then made up to 10,000 grains or one liter. Ten grains or 1 c. c. of this solution is equivalent to 0·1 grain of chlorine. The bleaching powder solution may be prepared precisely as I have already described. This method of making up the solution entirely in a large mortar is, I think, more easy of execution and quite as satisfactory as that of transferring the solution and sediment with repeated rinsings to a measuring flask. One-tenth of the bleaching powder liquor is drawn by a pipette, and delivered into a smal beaker. The arsenious solution is run into this from a burette graduated into cubic centimeters or grains to correspond with the other measures used. The operation is completed when a drop of the solution, lifted out upon a glass rod, no longer gives a blue or violet coloration when brought into contact with a slip of starch paper. The starch paper is prepared by soaking filter paper in a solution of iodide of potassium and starch. When dried it is cut into slips and preserved in stoppered bottles. No objection has been raised to this process, which, no doubt, gives accurate results, but it will be manifest that several of the precautions necessary to be observed in the execution of the iron process are quite as important in this. For paper-makers who have not the requisite laboratory appliances for delicate and accurate work the arsenious solution could be prepared in the same way as recommended for the standard sulphuric acid.

The chemical agents which next claim our attention are the various aluminous compounds used to precipitate the resin from the resin soap, and also for preserving animal size from putrefaction. The nature and effects of alum and the various alum substitutes form perhaps the most important chemical study connected with the paper trade. The only valuable constituent of all these substances is soluble alumina; this agent is chemically companionized with sulphuric acid, forming sulphate of alumina, and it not unfrequently happens that there is more of the acid in the article than is required to form sulphates with the bases present; the excess is, consequently, a free and very active agent, asserting its presence injuriously in various ways, some of which have already been commented upon. Alum, which is the purest and best known of the agents referred to, is a crystalline substance, consisting of sulphate of alumina, sulphate of potash or ammonia, and water, forming what is known in chemistry as a double salt. The composition of the potash variety may be thus symbolized:—$Al_2K_2SO_4 + 24H_2O$; its crystalline form is that of the regular octahedron. The ammonia variety may now be regarded as little better than a chemical curiosity, the extensive development of the Strassfurt potash deposits having greatly cheapened this material, while, on the other hand, the largely increased agricultural demand for ammonia has raised its price enormously, thus placing it beyond the reach of the alum maker. There is no cause for regret in all this, as the potash variety is the more regular and serviceable article.

"Sulphate of alumina" consists essentially of sulphate of alumina, but is always more or less contaminated with free acid. This article is not, like alum, a chemical compound of definite composition; the amount of the soluble alumina salt varies through one or two per cent., while the other and worthless constituents are mixed up in all proportions. There is but little insoluble matter in this agent, and in this is found its chief difference from alum cake, which usually contains about 20 per cent. The latter has generally a smaller proportion of free acid than the former.

Alumino-ferric cake, which is a comparatively new aluminous agent, is manufactured from the mineral bauxite by a process which renders the exclusion of free acid from the product easy.

Knowing something of the uncertain composition and the infinite trouble sometimes caused by the extreme acidity of alum substitutes, I, in view of these lectures, asked all the paper-makers in the kingdom to send me samples of the aluminous agents they were using, that I might be enabled the more fully to investigate this subject. In response to the request I received a great number of samples, and also a number of letters stating that the writers used nothing but alum crystals, the composition of which did not require investigation. The various makers' samples were arranged, and two ounces of each sample ground up together, to form one average sample; the result of analysis showed the various agents to contain sulphate of alumina, free sulphuric acid, and iron.

Maker.	Substance.	Sulphate of Alumina.	Alumina.	Free Sulphuric Acid (H_2SO_4).	calculated to Fe_2O_3.
H. D. Pochin & Co.	Sulphate of alumina.	40·34	12·10	4·72	·15
McArthur & Link...	do.	41·68	12·50	3·70	·13
H. D. Pochin & Co..	Aluminous cake.....	42·34	12·70	·30	·28
Cochrane & Co.....	do.	38·54	11·50	2·06	·35
Winser & Co	do.	40·68	12·20	1·24	·25
Peter Spence.....	Alumino-ferric cake.	48·21	14·46	none	·77
Foreign	Sulphate of alumina.	48·54	14·56	none	none
Theoretical	Alum crystals.....	36·12	10·83	none	none

These results are instructive and require little comment on our part. All the British makes contain more or less iron, and all except Spence's alumino-ferric cake contain free sulphuric acid. The foreign make, of which I received three samples, is free both from iron and acid, and is certainly a very fine product, well suited to the wants of the paper-maker; I understand, however, that the price is such as to put it beyond the reach of the makers of all but the very highest classes of papers. It will be observed that the cake made by Mr. Spence—who is so widely known for his scientific research and his enterprise and success as a chemical manufacturer—contains a relatively large proportion of iron, which no doubt renders it less suitable for some of the finest white papers, but for news and most ordinary classes this will not interfere with its value, which, as a sizing agent, must rank very high, owing both to its high percentage of alumina and the entire absence of free acid. Alum itself is singular in containing neither free acid nor insoluble matter, and in the uniformity of its composition, but it must not be forgotten that the sulphate of alumina in it, as well as in all the substitutes, is an acid salt liable to act upon strainer plates and machine wires if used in excess. The object in using sulphate of alumina in any of its forms in the sizing process is, as has been already indicated, to precipitate the resin of the resinate of soda. It must be borne in mind that that agent contains but a comparatively small proportion of soda, and that when more sulphate of alumina is used than is necessary to supply sulphuric acid to the soda, and thus precipitate the alumina, the excess retains its acid character. When the aluminous agent contains free acid, this will first act upon the resinate, forming a neutral soda salt, and precipitating free resin, which I have already stated to be undesirable in the pulp; using excess of such an agent, both evils will accrue. By properly apportioning the precipitating agent to the resin to be precipitated, acid pulps may be entirely avoided. Of course this result can only be obtained in a satisfactory way when the precipitating agent contains no free acid; when it does, neutrality may still be secured, but always at the expense of so much resin being precipitated free. Both alum and alum cake contain a large percentage of water, which some consumers seem to regard as an important matter, and choose those which contain least. This is a very absurd procedure; the fact of one cake containing 10 or even 20 per cent. of water more than another is of no consequence whatever, the question of real importance being which contains most soluble alumina and least free acid, and, secondary to this, which contains the least iron and insoluble or gritty matters.

The estimation of alumina is a matter of some nicety, and not to be undertaken by any but experienced chemists. It cannot be done by any simple volumetric method, such as I have described as suitable for soda and chlorine, and even when estimated by a trained chemist in a well-appointed laboratory, great care must be taken to secure strictly accurate results. Alumina is precipitated from the filtered solution by ammonia, but the precipitate is liable either to be too light or too heavy, just as certain precautions are observed or neglected. For details of the process I must refer to Fresenius, or any of the other leading analytical authors.

Of the minor chemicals we need only briefly notice hyposulphite of soda, or antichlor, used to neutralize the acidity of the bleached half-stuff. The action of this agent has already been described. The agent itself is composed of a sulphur acid containing a relatively large proportion of sulphur to the oxygen combined with it, and sodium oxide, with the constitution of which we are already familiar. Like most other crystalline bodies, its composition does not vary very much; if contaminated to any serious extent, it will be by the admixture of foreign crystalline substances, deliberately added to reduce its value.

The strength of the oil of vitriol supplied to the mill will be ascertained by an ordinary hydrometer, while its freedom from color will sufficiently indicate its purity for all paper-making purposes.

Before discussing the question of the disposal of the impure water discharged from various parts of the paper process, I may state that a laudable effort has been made by Mr. Wm. W. Ladelle to re-burn the waste lime resulting from the causticizing process and the preparation of bleaching liquor. I have seen the process in operation, and, while it has not yet established its claim to be a complete success, it is an effort in the right direction, and will, I trust, ultimately accomplish all that can be desired. The disposal of these waste products is really a vexing question, and I am sure we must all wish Mr. Ladelle and his co-workers success in their efforts to convert what is at present a gigantic nuisance into a useful agent.

Many and varied have been the schemes proposed for the purification of waste engine and machine waters. Let the fact that the millowners of the North Esk—who have already adopted every "practicable and reasonably available means" of purification—are going forward in the present session of Parliament with a bill to empower them to take a pipe to the sea at a cost of over £100,000, testify to the insufficiency of them all. No doubt much has been accomplished on the stream referred to. I have, myself, devoted nearly four years to the problem, and considering the extent of the industry and the smallness of the flow of water, the result is not to be despised; still, however, as the law of Scotland stands, the riparian properties are entitled to demand absolute purity, even at the expense of stopping the industry altogether. So long as common law is allowed full sway in this direction, the Rivers Pollution Prevention Act of the year before last will be a dead letter. The old law is far more powerful and certain in its action than the new. The latter aims at the purification of streams from manufacturing refuse, having a care that the industries involved are not unduly harassed, whereas the former comes down unreservedly upon all polluters, demanding immediate and complete cessation of the pollution at any cost.

I am convinced that no process of filtration is applicable to the purification of the waste discharges referred to, until at least the grosser portion of the impurities are removed, either by simple subsidence or by precipitation with chemical agents, and I am further convinced that purification by precipitation with chemical agents is a delusion. No doubt the sedimentary matter may be very thoroughly separated, and an apparently pure discharge be the result; but I have yet to learn of a process that will reduce the grains of polluting matter, soluble and suspended, per gallon to a lower point than a good settling system without any chemicals will do, especially if the effluent water from the settling system is passed through a simple ash filter before being discharged. Chemicals are not to be had gratuitously, and their application on a large scale involves both plant, steam, and labor. It is better, therefore, to spend a little more money upon a well arranged system that will work itself and require comparatively little attention, than a little less upon one that will involve a constant outlay.

Better than all the schemes of purification to which I have alluded, however, is that which begins in the mill itself. Let the boiling, cooling, and bathing liquids be so worked that the boiled materials may go into the engines so clean as to require little further washing; a better out-turn will be the result, and one half of the pollution obviated; and let almost the whole of the machine water be collected and rinsed, which will often be done at a profit, and will also conserve the purity of the streams. If precautions are taken under each of those heads, the volume and intensity of the polluted liquids to be purified will both be reduced, and the object aimed at made more easy of accomplishment. An efficient settling system should be capable of containing from 24 to 36 hours' flow of the discharge; if the liquids are longer in the system they are apt to putrefy, especially in hot weather, with a result which is certainly no improvement upon the original condition of things. Every settling system should be provided with the means of discharging and draining the sludge as it accumulates. If the drainers be well constructed, the sludge should lift in a caked form, easy of removal to the rubbish heap.

The system of purification which we have described in our report to the Rivers Pollution Commission, and which will be found, along with the accompanying plans, in their Fourth Report, Vol. I., pages 20 and 62, and Vol. II., pages 326 to 334, has been but little improved upon, notwithstanding all the efforts that have been made to minimize still further the pollution of our rivers from paper manufactories.

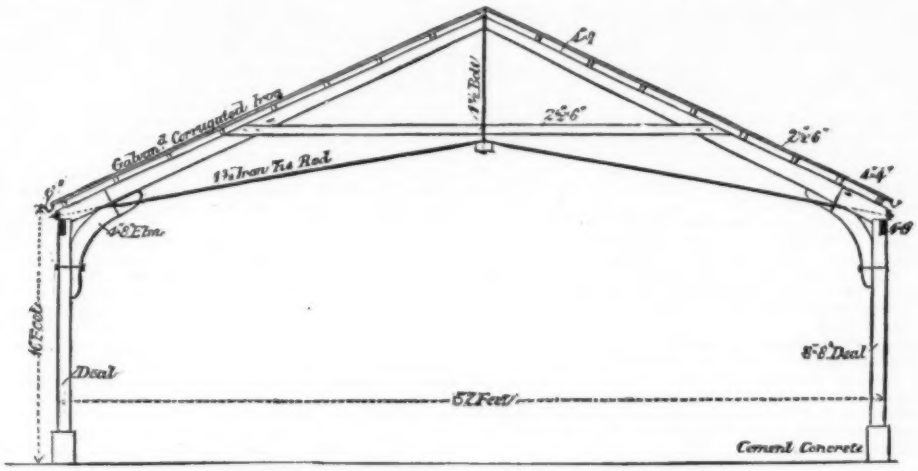
ENGLISH FARM BUILDINGS.

WE give an illustration of the conversion of a set of ill-arranged farm buildings into a compact and almost wholly covered homestead.

The two principal buildings—the barn and the stable—being of a good substantial character, were retained, but all the other buildings were pulled down, being either dilapidated or, as in the case of the shelter sheds, narrow and low as well as out of repair.

By comparing the plan "as it is" with the plan "as it was," the extent of the alterations and additions will be seen.

The principal feature, and perhaps the only one, to which special attention need be called, is the adoption of covered



SECTION OF COVERED BARN YARD

yards, of which two—60 × 50 feet each—are placed in immediate communication with the mixing floor formed out of the south bay of the barn. The roofs of these yards are covered with pantiles, interspersed with numerous glass tiles affording all necessary light. There are arched openings in the front wall which, with the ridge tiles raised alternately, and the free passage of air between the pantiles themselves, provide ample ventilation without the draught so often complained of in covered yards. The middle bay of the barn, from its proximity to the cutting floor, which is over the mixing floor, becomes a straw bay, and the north bay remains available for a dressing floor with a granary over.

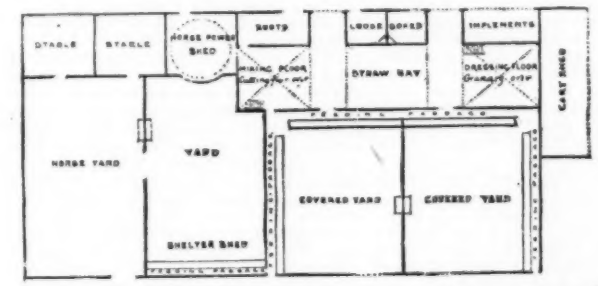
The turnip and chaff cutters and the cake crusher are worked by horse power from the building adjoining the root store and the cutting and mixing floors. Water is supplied by means of a large underground tank, to which the roof water is conveyed, and thence pumped into a cistern commanding the troughs in the yards.

The farm upon which this homestead stands is in Norfolk, and consists of 300 acres, of which about three-fourths are arable, and the remainder pasture.

The additions and alterations were carried out under the direction of Messrs. Bailey-Denton, Son, & North, of Whitehall Place, London, and cost about $6,000.

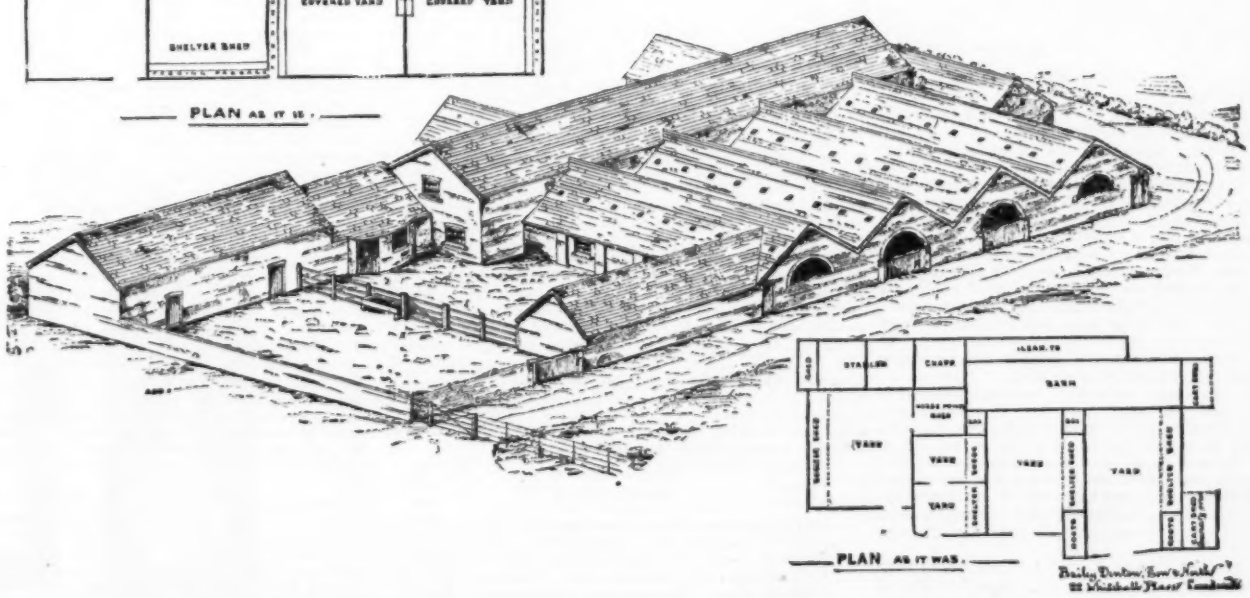
We also give a sectional elevation showing the mode of constructing the roof for a covered barn-yard, designed by E. B. Gibson.

For the foregoing we are indebted to the *Agricultural Gazette*.



PLAN AS IT IS.

A COVERED HOMESTEAD



COVERED HOMESTEAD ON A NORFOLK (ENG.) FARM.

TRANSFERRING BEES.

I AM often asked: "When is the best time to make transfers?" Experts can do it any season of the year, but beginners had better not transfer their bees until fruit trees get in full bloom. Nearly every experienced bee-keeper has his own mode of transferring, which he thinks a little superior to that of his neighbor; but I do not think that it matters so much what peculiar manipulations are practiced only so the following ends are achieved:

First. The preservation of the bees.

Second. The adjustment of the worker comb from the box hive into the frames in a straight and secure manner, preserving the natural arrangement as near as possible.

Third. An abundance of food, either honey in comb (which is to be preferred) or sugar syrup, until they can gather plenty from natural sources.

Fourth. Security from robber bees or a condition to enable them to defend themselves from the attacks of strange bees.

I prefer to make my transfer in a close room, with all windows darkened but one. There should be no openings for the transferred bees to get out nor any for strange bees to get in. In this room you want a table on which to lay your frames, comb, etc., a basin of water and a towel, a saw, hatchet, chisel, and a long bladed knife to cut the comb loose from the box hive. A few large shallow dishes may be required upon which to lay comb containing honey. For the purpose of securing the comb in the frame, I use small sticks split from yellow pine, about one-fourth inch wide and one-eighth inch thick, and long enough to project one-fourth inch beyond the top and bottom of frame. The ends of these sticks are notched and secured by fine annealed wire. They are wired at the bottom ends in pairs, and a wire about four inches long is attached to one of the upper ends of the pair, which is intended to be merely wrapped around the end of the opposite stick when adjusted to the frames. Rubber bands can be used in place of the wire. Four or five pairs of these sticks are usually needed to one Langstroth frame. The advantage of sticks over cements and glues is that you can fasten wet comb or comb filled with honey or brood. When the comb is clean and dry a cement made by melting two parts of bees-wax and one part of resin can be used. Wire, twine, thorns, etc., are also recommended by some apiarists

Whatever sort of appliance for holding the comb in the frame is decided on, it should be provided and ready before you commence the operation of transferring. In fact have everything ready, so there may be no delay.

When all is ready, go to the hive to be transferred and blow some smoke in at the entrance, turn it mouth up, and throw a cloth over it, and carry it into the transferring room. Place an empty box or gum, of the same size, over its mouth, and close the cracks around with a cloth so no bees can escape. Rap briskly on the hive with the hand or a stick for ten or fifteen minutes, and if the colony is strong and the temperature of the room warm, the bees will ascend into the box, which can now be carefully removed and partially placed on one side of the table. When the colony is weak the bees are sometimes reluctant to leave their combs. With such stocks it is not necessary to "drum them," only smoke them back and proceed to remove the combs.

Pry off the side of the hive that is parallel with the comb, and proceed to remove it with the long bladed knife. As removed, lay it upon the table. If the bees come in front, smoke them back. When all the comb is taken out of the hive, proceed to fit it to the frames. Endeavor to arrange it in the frames in the same order in which you found it. To do this, it may be necessary to cut through brood or through comb filled with honey, but the sticks will always hold it if they are properly adjusted. It is best to reject the drone comb, for when the workers want drones they will form many drone cells in the lines of union of the different pieces of comb. All the small pieces of worker comb can be filled in if care is used. As the frames are filled place them in the hive—the brood in the center. When all the frames are replaced, cover with a quilt or honey board and close the hive. Now gather up your box of bees and shake them on a cloth, which should be tacked to the alighting board, and they will enter like a swarm. If any bees collect on the window panes, brush them off with a wing or a tuft of grass into a tin pan and pour them in front of the entrance.

After the bees are hived, close the entrance so that only one bee can pass at a time; see that no honey is smeared on the entrance board; and after the hive is carried to its stand, set some brush or weeds or grass up in front of the entrance to ward off robbers. An ounce of prevention in this matter is much better than a pound of cure.

If the weather is cold, I heat up my room with a stove; and if I have only a few transfers to make, I do it in the afternoon, and after the bees all get in the hive I tack wire cloth over the entrance, darken the room and allow them to remain forty-eight hours before I carry the hive to its permanent stand. Keep the room heated at the time. This allows the bees a chance to clean up and set things to rights, so when they are let out they are fully prepared to resist the attacks of robbers.—*Bee-Keepers' Magazine.*

THE TOAD AND ITS HABITS.

FORMERLY the toad was considered a venomous reptile, but in our day its habits have been more carefully observed, and its great value to the pomologist and gardener has been fully established, on account of its propensity for destroying insects, especially those injurious to vegetation. We should, therefore, sedulously cultivate the friendship and crave the assistance of the insectivorous reptiles, including the snake, as well as that of birds.

Every tidy housewife detests the cockroach, mice, and other vermin. Two or three domesticated toads would keep the coast clear of these, and would be found more desirable than a cat, as they are wholly free from trespassing on the rights of man as does the cat. The toad is possessed of a timid and retiring nature, loving dark corners and shady places, but under kind treatment becoming quite tame.

Many instances might be cited of pet toads remaining several years in a family, and doing valuable service with no other compensation than immunity from persecution. All that is necessary to secure their co-operation, indoor or out, is to provide them with cool and safe retreats by day, convenient access to water, and they will go forth to the performance of their nocturnal duties "without money and without price."

In Europe toads are carried to the cities to market, and are purchased by the horticulturist, who, by their aid, are enabled to keep in check the multiplication of the insect tribes which prey upon their fruits, etc.

No one can study the anatomy of this reptile without being convinced of its perfect adaptation to the sphere which it fills in the economy of nature. Its tongue, which is capable of great elongation, is attached to the anterior portion of the lower jaw, its free end, when the toad is in repose, reaching down to the borders of the stomach. The moment the toad sees its prey, its eyes sparkle, its toes twitch, and, quicker than the eye can follow, the insect is transfixed and conveyed to the stomach of the captor.—*Young Scientist.*

DIVISIBILITY OF GOLD.

At a recent meeting of the California State Geological Society, Mr. Henry G. Hanks read the following paper on this subject:

Having recently had occasion to refer to statistics showing that gold coin loses an appreciable amount even in a single handling, and being desirous, in connection with my investigations, to examine microscopically the gold dust resulting from such abrasions, I asked Mr. L. A. Boynton, of the United States Treasury of this city, to brush out the wooden tray in which large sums of gold coin are daily handled, and when he had accumulated sufficient to see the gold to send it to me. He kindly complied with my request, and I am able this evening to call your attention to some interesting facts, which have developed themselves in the examination.

I have prepared a slide for the society's collection, in which the gold is mounted dry, after first partly removing the impurities with which it was mixed. It will be seen, however, that there still remain coal, sand, fibers of wood and cotton, hairs, etc. In washing out the extraneous matter, the finer particles of gold floated on the surface of the water, and I found it impossible to cause them to sink, although I tried every plan I knew of. This experiment would seem to prove the truth of the oft-repeated statement of miners, that much free gold escapes them from this cause.

On examining the slide under the microscope, it will be seen that the gold is invariably in the form of scales, and much resembles the natural gold scales found on the beach sands at Cape Blanco, except that in the latter the edges and face of the scales are rounded by attrition in being washed about by the waves.

It has been a source of wonder to gold miners that nearly all placer gold is found in flat pieces. Some ingenious theories have been advanced to account for it. The sample I present this evening would seem to indicate some law which governs the form of fragments. I admit I cannot clearly understand how rounded masses of metal like gold coin should react on each other mechanically and produce flat fragments, as shown in the specimen.

To give an idea of the size of the particles of gold, I have measured some of them in decimals of an inch, and I find them to vary from ·003x·001 to ·0425x·0235.

I have also measured a large number of the gold scales from Port Orford, and find an average of .0095 in diameter by .00384 in thickness.

The samples were washed from the beach sands found a few miles south of Cape Blanco, on the coast of Oregon. Ten of the scales, selected at random, and melted into a button, weighed .0021327 grammes. From this weight I have calculated the number of such scales which would be required to make up the weight of an ounce troy.

If I have made no mistake in my figures, the number should be 142,468, and yet these gold particles are large as compared with those usually found in quartz.

In collecting gold from quartz by amalgamation, it has been found that, in most parts of California, any mine producing rock that will yield, by simple milling process, $10 to the ton of 2,000 pounds and in sufficient quantity to keep a mill constantly running, will pay well to work.

Most of the best paying mines in California do not produce rock in which gold is visible to the naked eye. It requires long search to find a piece of rock showing free gold.

When the tailings of a quartz mill are examined microscopically, the importance of reducing the ore to a state of extreme fineness will be apparent, for if gold is not absolutely free it cannot be collected by mercury.

Recent investigation naturally leads to the opinion that gold in a state of extreme division is omnipresent in the earth's crust. T. Sterry Hunt, in his work, "Chemical and Geological Essays," quotes Sonstadt to show that the sea water on the British coast contains, besides silver, gold in solution, estimated by him to be about one grain to a ton of water. Mr. J. Cosmo Newbery, Chemist of the Geological Survey of Victoria, Australia, has made some very interesting investigations bearing on the divisibility of gold. He found that the water in certain gold mines contained gold. The timber used to support the mine was carefully assayed and in nearly every case was found to contain gold. R. Brough Smyth, Chief of the Survey, came to the conclusion that the gold was precipitated from solution.

Mr. Newbery had reason to believe, from examination of specimens, that gold was being deposited in many mines. He thinks, however, that finely divided gold is held in suspension in mine water, but not in solution. A sample of mud deposited from mine water of a mine, on Hasler's line of reef, Sandhurst, was examined by careful washing, and the heavier particles were found to consist of auriferous pyrites and free gold. The particles of gold were large enough to be recognized by the microscope. They were in irregular flattened grains.

Dr. Oxland, who was formly Manager of the Borax Lake Company's works, has given a very interesting account of the deposition of gold with cinnabar, free mercury, sulphur, boracic acid, silica, etc., at the sulphur banks situated on the margin of Clear Lake.

He says: "These phenomena present indubitable evidence of the volatility of gold and silver, mercury and iron, in presence of aqueous vapor, associated with sulphureted hydrogen, carbonic acid and boracic acid."

Some years ago, in Calaveras county, an old furnace—used in roasting pyrites preparatory to treatment by chlorination—was torn down, and the roof was found to be coated with gold. A specimen is preserved in the museum of the University of California. Here is proof that gold is volatile at a comparatively low temperature. It has long been known that it is volatile at a high temperature, and advantage is taken of this fact in the purification of platinum.

On the Pacific coast, gold is found in the most unexpected places. There is scarcely a formation which does not contain gold in greater or less quantities. It is also found associated with minerals not usually considered its associates.

To illustrate this fact, I have brought, for inspection, several remarkable specimens:

1. Gold in pyrolusite.
2. Gold in steatite.
3. Gold calcite. In this specimen the gold is deposited on the wall-rock of the mine, apparently by the same agencies which deposited the calcite.
4. Gold on pyrites. It will be remembered that I exhibited a similar specimen at a former meeting, and called attention to the globules of gold, which seemed to be squeezed out of the crystals of pyrites, or to have been deposited on their surfaces in a manner not easily explained. The specimen I have brought this evening is more remarkable than those formerly shown.

I have long believed that the gold in sylvanite, nagyagite, calverite and other telluric minerals was a mechanical mixture and not chemically combined. Experiments I have made from time to time have convinced me that my opinion was correct. I have prepared a specimen of telluric gold, from Sunshine, Colorado, which is worthy of your attention. You see that the gold is in a state which would preclude the idea that it had been chemically combined with the tellurium, in which case the gold would have been an amorphous powder rather than the semi-crystalline form shown. The specimen has been repeatedly boiled in nitric acid, by which the tellurium has been dissolved.

It must be admitted, from the experience of the last 25 years, that gold exists in minute quantities in many rock formations which will not pay to work. On the other hand, many mines, which will scarcely pay at the present time, will become productive as our quartz milling machinery is improved. Much gold is lost in California by unskillful milling.

Although the modern quartz-mill is a marvel of mechanical skill and ingenuity and does its work rapidly and well, yet it has not reached perfection. The problem for the future inventor to solve will be to construct machinery which will reduce the rock to an impalpable powder, to set the gold free and to collect it without mechanical loss of either gold or mercury.

PRESENCE OF OXYGEN IN METALLIC SILVER.

By M. Dumas.

The author, after referring to the discussion which has recently taken place on the fundamental principles of the atomic theory, admits that there is another question which has the most important bearing upon the very nature of matter, and which still remains open. While the equivalents of simple bodies when compared with that of oxygen do not exhibit any appreciable relation, we had formerly merely to take the equivalent of hydrogen for unity in order to find that the equivalent of carbon might be taken as 6, that of oxygen as 8, that of nitrogen as 14, that of sulphur as 16, of calcium as 20, of iron as 28, etc. The equivalents of elementary bodies seemed therefore represented by multiples of the equivalent of hydrogen by whole numbers. For those who believe in the unity of nature these experimental results gave great force to their opinion, and rendered it permissible to suppose that the reputed elementary bodies might result from the simple aggregation of similar molecules varying merely in number or in arrangement in each case. These results have been called in question. From a mere practical point of view chemists may content themselves with the notions on the weights of equivalents already acquired. Such, however, is not the case in a purely philosophical light, and it was necessary that experiment should decide whether the equivalents of simple bodies are or are not multiples of one and the same fundamental unity of whole numbers. In this discussion it is not useless to remember that we have never been deceived by the balance, the most perfect of all instruments, but often, on the other hand, by faults in calculation, and especially by involuntary errors as regards the purity of the substances employed. Berzelius, the creator of numerical chemistry, convinced (as he had the right to be) of the precision of his experiments, maintained their rigor to the third decimal. But it would suffice to refer to a vacuum the apparent weight of the bodies upon which he operated—a correction which he had neglected—in order to modify the last decimals of his figures. As concerns the gases, all the determinations of density made in the first years of the century, compared with that of hydrogen, vary a little from the simple ratios which they ought to present. Oxygen ought to appear 16 times as heavy as hydrogen, nitrogen 14 times, carbonic acid 22 times, etc. Experiment certainly gave results approximating to these numbers, but deviations were still present which ought not to have been met with. It had not then been observed that every gas collected over a liquid has lost its purity, and that in order to operate upon a pure specimen it should be conveyed directly from the generating apparatus to that where it is to be operated upon. When this modification was introduced, the weights of nitrogen, of oxygen, and carbonic acid for one and the same volume became, we may say, exact multiples of the weight of hydrogen by whole numbers. We put aside, for the moment, as of no importance, the question whether this unity should be hydrogen itself, or double its weight, that is, 1 or 2, since we have to do, not with absolute numbers, but with ratios. May we not consider the following figures, determined by experiment, as expressing ratios in whole numbers?—

Hydrogen	1·00
Carbon	6·02
Lithium	7·02
Oxygen	8·00
Nitrogen	14·04
Sulphur	16·02
Calcium	20·01
Sodium	23·04

Is there not here the indication of a natural law? The irregularities, even where greatest, may they not be ascribed to an imperfection in the experiment rather than to the constitution of the bodies in question? I have never ceased pursuing the thought that to determine the absolute ratios of weight between the equivalents it is necessary, not merely to take materials very pure, reactions very simple, and weights referred to a vacuum, but to employ, further, some precautions which have been overlooked. I think I may now add that when it is needful to carry precision to its utmost limit we cannot, in many cases, consider the weight of bodies as exact until they have been kept in a vacuum at an elevated temperature unless they no longer evolve anything, and until the barometer connected with the apparatus remains at its normal height. It is not sufficient for bodies to remain for a long time in a vacuum in the cold, or for a short time in heat, or to be heated to redness at the common pressure. This may be shown by an example. Among the compounds which have played a part in the determination of equivalents the chloride of silver figures in the first rank. By reason of its insolubility any soluble chloride may be transformed into chloride of silver with such facility that these reactions afford a very general means for ascertaining the equivalents of the elementary bodies. Still, if we compare the various syntheses of chloride of silver we find differences absolutely inexplicable. Thus, for 100,000 of silver, we find, according to—

Berzelius	132·700 of chloride.
Marignac	132·842 "
Stas	132·850 "
Dumas	132·870 "
Gay-Lussac	132·890 "
H. Rose	133·014 "

Among these numbers which is the correct one? No one will call in question the skill of the experimentalists. We must seek the causes of the discrepancy in the circumstances of the experiment, and they seem to lie in the state of the metallic silver used for conversion into chloride. Our colleague, M. Debray, had at my request prepared 1 kilo. of pure silver, using the common procedure for melting and granulating this metal, *i. e.*, fusion with the addition of a little borax and niter—a method pursued by most of the experimenters who have determined its equivalent or made use of it in the determination of others. I placed this silver in a flask of glazed porcelain connected with a Sprengel pump. I heated the flask, and soon, the temperature having risen to 400° or 500°, gas was evolved, and continued to escape for six hours, being collected in tubes over mercury. The flask was kept at from 500° to 600°, but without exceeding a dull red heat. When the disengagement ceased all the gas remaining in the flask was drawn out, and the temperature raised to the fusion of the silver. No further escape of gas took place. When the flask was cool a well-crystallized button of silver was found. The interior of the flask was partially covered with globules of distilled silver, but there was not a trace of that yellow tint which shows the formation of silver silicate. The button when carefully cleaned had the specific gravity 10·512, consequently higher than that generally ascribed to silver. The gas given off was pure oxygen, amounting in quantity to 57 c. c. at 0°, and 0·76 per kilo. of silver. Hence the silver experimented upon contained 999·918 grms. of silver and 82 milligrms. of oxygen. Another kilo. of silver, into which small successive portions of niter were thrown during fusion, was found to contain 226 milligrms. of oxygen, and only 999·774 grms. of real silver. It appears from these trials that in the very numerous experiments for the determination of equivalents which have been made with the intervention of silver the chemists who, having taken the necessary precautions for the purification of this metal, have granulated it after previous fusion in presence of borax, niter, and air, have placed it in the proper circumstances for the absorption of oxygen in proportions varying from 50 to 200 c. c. per kilo. These quantities are calculated to exercise a notable influence upon the results deduced from the synthesis of silver chloride, or the very numerous experiments which have served for determining the weights of elements by finding the quantity of silver necessary for the decomposition of their chlorides. The oxygen augments the apparent weight of silver employed, and diminishes the weight of the chloride obtained. The ratio of the chlorine to the silver is therefore necessarily altered. The results obtained by Marignac and Stas, or even by Berzelius, in place of the proportion 108:35·47 would give 108:35·50, as found by Gay-Lussac and the author, if the correction for the presence of oxygen were applied to their experiments. But there remain other objections to be raised before the problem of the numerical relations existing between the equivalents of simple bodies can be considered as solved. The conditions of this reciprocal action of oxygen and silver deserve a close examination. If the metal is heated to dull redness in a vacuum, a moment arrives when, all the gas present having been extracted, if the silver is fused and oxygen permitted to reenter the apparatus, it is absorbed rapidly. The mercury reascends, and keeps at the height of 48 to 50 centimeters for entire hours, even at a temperature at which porcelain softens. We may thus determine the tension of the solution of oxygen in melted silver, or the tension of dissociation of the compound, if we consider the product as a chemical combination. If the apparatus is allowed to cool the silver is solidified, and a sudden escape of oxygen takes place, but the metal, even in a vacuum, does not give off anything approaching to the quantity of oxygen absorbed. Thus, according to these experiments, silver which has absorbed oxygen does not lose it in the cold in a vacuum. At from 400° to 600° in a vacuum the escape is rapid, but tends to cease above a cherry-red heat. When the silver softens, and especially when it melts, the phenomenon is reversed, and the absorption of oxygen becomes rapid. On solidification a quantity of the oxygen is lost, though considerable quantities are still retained. The experiments of Lucas, Chaudet, Gay-Lussac, and Graham have shown that silver possesses the power of dissolving oxygen, and of losing a part again on solidification. If this fact has not been taken into account in the delicate researches to which this metal has been devoted, it is because the oxygen was supposed to have entirely escaped at the moment of solidification. The interesting researches of M. F. Le Blanc on the power which litharge possesses of dissolving oxygen on fusion, and losing it again on cooling, refer doubtless to a phenomenon of the same class.—*Comptes Rendus, Chemical News.*

Liquefaction of Gases.—M. Cailletet.—The author inclosed in the tube of his pressure apparatus dry air deprived of carbonic acid, and refrigerated the upper part of the tube *only* with nitrous oxide. When the pressure had reached 200 atmospheres, small threads, doubtless liquid, were seen to flow down the lower part of the tube. Ether when flowing in a tube presents the same appearance. When these threads came in contact with the mercury below the refrigerant, the pressure was then increased to 255 atmospheres, when the liquid threads became more numerous and more distinct. At 310 the mercury was frozen, and was covered with hoar-frost, doubtless frozen air.

Gallium.—Recently, at the Académie des Sciences, M. Lecoq de Boisbaudron exhibited a bar, a sheet, and several crystals of the new metal, gallium, which is harder than iron, yet melts at under the heat of the finger, its freezing point being at about 30°. It is proposed to use it for a thermometer going up to red heat. 5,000 kilogrms. of ore had to be worked down to get 60 grms. of metal. It will now be possible to investigate its physical properties. It adheres to glass, and is very brittle; the color is nearly that of steel, and the crystals are octahedra.

ON THE FORMATION OF HAILSTONES, RAINDROPS, AND SNOWFLAKES.*

THE author commences by recapitulating some of the leading points in a paper which he read before the same society on October 31, 1876, "On the Manner in which Raindrops and Hailstones are Formed." In this paper he had shown that the aggregation of the small cloud particles into raindrops or hailstones is sufficiently accounted for by the fact that the larger particles descend faster than the others, and consequently overtake those immediately beneath them, and, combining with these, form still larger particles, which move with greater velocity, and, more quickly overtaking the particles in front of them, add to their size at an increasing rate. He also showed that the shape and structure of ordinary hailstones was exactly such as would result from this manner of formation. For he had observed that the shape of hailstones was not as it at first sight appeared, that of more or less imperfect spheres, but that of more or less imperfect cones or pyramids with rounded bases, the conical surfaces being striated, the striæ radiating from the vertex, the texture being that of an aggregation of a number of small ice particles without crystalline form, being packed more closely together toward the base or rounded face of the stone. In this paper the author had reverted to the possibility of making *artificial hailstones* by blowing a stream of frozen fog against a small object, making, as it were, the cloud to rise up and meet the stone, instead of the stone falling through the cloud.

He had not, however, then overcome the difficulty of obtaining such a stream of frozen fog, but gave two sketches of plaster stones, which, as far as their shape and the striated appearance of their surface were concerned, closely resembled hailstones, and which plaster stones had been obtained by blowing some finely-divided plaster of Paris against small splinters of wood by means of a jet of steam.

In the discussion which followed the reading of that paper Dr. Crompton suggested the ether spray, such as is used in surgery, as a means of obtaining a frozen fog, and

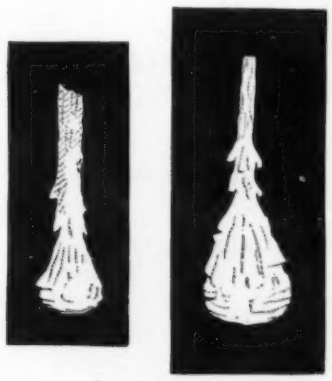


FIG. 2.

Prof. Reynolds explains how after various attempts he had succeeded in combining a spray of ether and water so as to form artificial stones. He then proceeds as follows:

The apparatus is shown in Fig. 1. It consists of a brass tube half an inch in diameter, one end of which is connected with bellows capable of maintaining a constant pressure of about 18 inches of water; on the other end of the tube is a cap, over the end of which is a flat plate or diaphragm having a central opening 1/6 of an inch in diameter which forms the aperture for the blast. Entering through the sides of the main brass tube are two small brass tubes which reach to within 1/2 an inch of the plate and into the ends of which are sealed fine glass capillary tubes, the glass being very thin; these protrude just through the middle of the aperture, the one about 1/16 of an inch and the other 3/16. Through these tubes the water and ether are separately introduced into the blast to form the spray, and it is mainly on the adjustment of these tubes that the efficiency of the apparatus depends. It is essential that the ether tube should be slightly the longest, otherwise the ends become stopped with ice, and I find it better that the ether tube should be somewhat larger than the water tube. The bore of the tubes must be very small, but this is not sufficient, for unless the glass is very thin the spray will not be finely divided. Both the ether and water are forced through the tubes from bottles by connecting the interiors of these bottles with the bellows, and the quantities of ether and water are regulated either by raising and lowering the bottles or by means of the cocks in the pipes.

The tube is fixed in an ordinary retort stand, so that the blast is vertical. If then a small splinter of wood is held

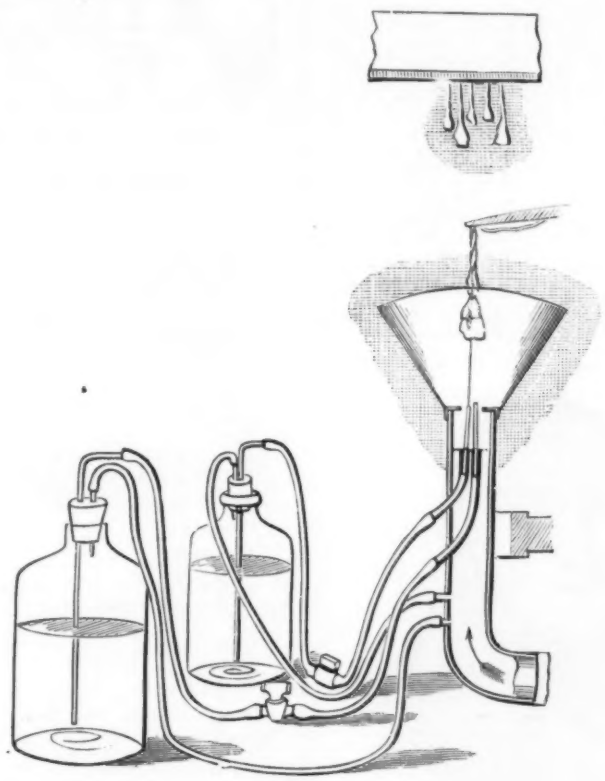


FIG. 1.

pointing downward into the spray, a lump of ice forms on the end of the splinter, and this lump has all the appearance of the hailstones. It is quite white and opaque, it is conical in form and has a rounded base and striated surface.

In this way I have formed stones from half to three-quarters of an inch in diameter. When, however, the stones are growing large, it is necessary to move this splinter so as to expose in succession all parts of the face of the stone to the more direct action of the spray.

When using this apparatus in a warm room I have found it best to fix a pad of blotting paper over the jet at a height of 10 or 12 inches. The surface of this pad is cooled by the spray and prevents radiation from the ceiling, which otherwise tends to melt the top of the stone. For a similar reason I have found it well to surround the blast with a wide cylinder or inverted cone of paper, which keeps off radiation without interfering with the action of the jet.

By sticking several pieces of wood into the pad, pointing downward, a number of stones may be made at once.

In Fig. 2 a medium-sized stone as well as one of the largest stones are shown attached to the splinters of wood. The surface of the cone, where continuous, is truly conical, or rather pyramidal, but this surface is broken, as it were, by steps, and a very marked fact is that all the continuous surfaces have the same vertex, and hence the different conical surfaces to which they belong have not the same vertical angle, the surface being exactly such as would be acquired by the fragments of a sphere so constituted that the fracture tended to follow radial lines.—*Nature.*

* Abstract of paper by Prof. Osborne Reynolds, F.R.S., read at the Manchester Literary and Philosophical Society.

LIQUEFACTION OF HYDROGEN.

By RAOUL PICTET.

THE author obtained hydrogen by decomposing potassic formiate by potassa. The hydrogen thus escaped is perfectly dry, and the residue is not volatile. The pressure reached 650 atmospheres before becoming stationary. The cold was about —140°. On opening the cock the liquid hydrogen escaped with vehemence, making a sharp hissing sound. The jet had a steel-blue color, and was perfectly opaque for the length of 12 centimeters. At the same moment a rattling was heard like that made by hail when it falls upon the ground, and the hissing became transformed into a peculiar noise, resembling that made by a fragment of sodium thrown upon water. Almost immediately the jet became intermittent, and shocks were felt in the cock at each escape. During the first jet the pressure fell from 650 atmospheres to 370. After closing, it gradually fell for several minutes down to 215 atmospheres, and then slowly rose to 225, where it became anew stationary. On re-opening the cock the jet issued in so intermittent a manner that it became evident that the congelation of hydrogen had taken place in the tube. This hypothesis was demonstrated by the progressive escape of all the hydrogen when the pumps were stopped and the production of cold arrested.

DIRECT PRINTING FROM GLASS NEGATIVES.

A COMMUNICATION which I made in 1876, respecting printing from glass negatives, was received with great interest in Berlin photographic circles, and from many quarters requests to sell the process reached me; but I could not make up my mind to do so, as I intended to work it myself, though circumstances have as yet hindered me. As, at the request of Herr Reising, the subject was lately broached again at Berlin, I shall throw a little light on the matter, and, for the benefit of those who busy themselves with similar experiments, shall publish the process and its applications for the general use.

Usually, in order to render negatives printable, they are coated with a solution of chrome gelatine when they have become perfectly dry. Thus one always gets a film of bichromated gelatine *above* the collodion film. It is also perfectly well known that by exposing such negatives to diffused light the lines become somewhat broader, because, even when the film is thin, the light works in from the sides. Toward the end of 1875 I tried to prevent this by forming a film of bichromated gelatine *in* the collodion negative film. In this attempt I succeeded completely, by taking the negative immediately after development, without drying it, fixing it, and washing it with water, and, *while still wet*, placing it in a thin solution of bichromated gelatine. When dry the upper surface was matt, and there was no coating of gelatine to be seen, though the collodion film had absorbed a sufficient quantity of gelatine and bichromate to render it printable after exposure to light.

Now, in order to produce with advantage such plates, in which, so to speak, the collodion films are rendered capable of being printed from, I proceed as follows:—Having developed, though not very powerfully, in the usual manner a negative upon an albumenized glass plate, and having fixed and washed the negative, it is placed in a solution previously prepared thus:—4·5 parts of gelatine are put to soak in water, and then, the superfluous water being poured off, fifty parts of distilled water are added, and it is allowed to melt; a solution of 5·5 parts of bichromate ammonia in one hundred parts of water is then added, and the whole heated to 60° R. The plate remains about five minutes in this bath. If large plates be used the solution may be poured over them, but then, before coating, the plate must be quickly rinsed with a little slightly warm water, and the coating with the gelatine solution must be frequently repeated. A sufficient quantity of the solution being poured upon a plate, the latter must be warmed in a horizontal position over a spirit lamp. If fumes rise from the solution, lift up the plate for a moment; then warm it again in a horizontal position until it becomes quite dry, but do not let it become so hot that the palm of the hand cannot easily be drawn across the back of the plate.

As the duration of the exposure of such a negative can never be exactly measured by merely looking at it or by using the common photometer, having well washed the back of the prepared negative I take a piece of sensitized albumenized paper, or paper prepared with a solution of a bichromate, and place it upon the film side of the negative; then, placing the whole in a frame, light through the glass. With the aid of this simple expedient I can always ascertain how far the action of the light has gone, cover parts that are too dark, and so on; but this requires skill, as in silver printing. Of course I use a black backing, in order to prevent any reflection of the rays of light. By this process, however, in spite of the white albumenized paper, reflection is little to be feared, as the chloride of silver absorbs all the rays of light.

When the finest lines of the image are distinctly visible, the ammonium bichromate should be washed out by laying the plate in cold water, and when dry the negative may be handed to the printer. For printing the finest rollers should be used. When damping it is advisable to put a little gum arabic on the edges, and to rub the surface of the picture with it. With regard to the preparation of the negative, I may mention that every collodion does not take up the same quantity of chrome gelatine; indeed, many do not absorb the solution at all, and with such one only gets a gelatine film *upon* the collodion film. The lithium collodion prepared by Dr. Kurz, of Wernigerode, is the best suited for this purpose. I believe that the lithium salt in this collodion plays a not unimportant *role*,* but as yet I have had no opportunity of experimenting in this direction.

Not only does this process furnish linear reproductions with the greatest delicacy in the lines, but it can also be made very useful in the case of photographs from nature.

It is principally for portraits that direct printing from the glass cannot be employed, since it does not admit of retouching the negative. Still, if a negative be prepared in the manner directed above, but only exposed until the shadows of the picture have become visible on the albumenized paper, and if the negative be then washed with water whose temperature is continually increased until it dries up, the negative will bear any required degree of retouching with a No. 2 Faber's lead pencil, and then with fine graphite rubbed on with a stump. If for such special cases a rough surface should be desired, add to the heated gelatine solution twenty parts of spirits of wine in which is dissolved one part of colophonium. When the necessary amount of retouching has been done coat the surface with a dilute solution of ammonia, and when that has dried let a coating of albumen and water-glass (such as Professor Husnik has repeatedly described) follow, and then employ the process described at the same time by Professor Husnik, or any other good lichtdruck process in which sheets of prepared albumenized paper are used instead of a scale photometer.

By the process just described lichtdrucks in several colors (chrome-lichtdrucks) may be produced by taking as many negatives of the subject in question as there are colors to be printed, and treating the negatives by the first process. All the parts that are not required are then worked out with a stump and graphite, and the outlines with lead pencil. With a certain degree of practice it is not necessary to prepare separate plates for the secondary colors, like green, orange, and violet, as by covering the parts more or less with stump it is possible to obtain with ease the most beautiful transitions and mixtures of tints. With the assistance of the bits of albumenized paper one may make any change during the exposure that may be thought desirable. Since Albert's process cannot be used by everybody, the process I have just described may yet find many uses.
—*Photographische Correspondenz.* HANS BRAND.

* Apart from the fact that the metals combined with the halogens exert an undoubted influence on the greater or less fluidity of the collodion, it is very possible that in the case in question the quality of the pyroxyline may exercise a real influence.—ED. *Ph. Cor.*

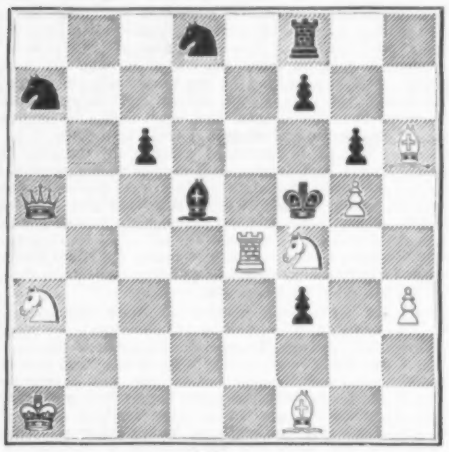
SCIENTIFIC AMERICAN CHESS RECORD.

[All contributions intended for this department may be addressed to SAMUEL LOYD, Elizabeth, N. J.]

PROBLEM No. 68. BY T. M. BROWN.

First Prize in the American Chess Congress of 1871.

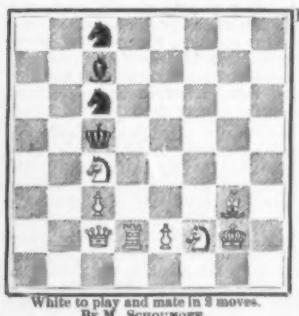
Black.



White.

White to play and mate in three moves.

LOUIS CHARLES DE LA BOURDONNAIS.



White to play and mate in 3 moves.
By M. SCHOUMOFF.

LIKE the illustrious Philidor, whose portrait appeared last week, the subject of our present sketch was a native of sunny France.

He was born in 1795, the same year in which Philidor died, and was a most worthy successor to take up the mantle of the great French champion, being one of the few of the old masters whom the world has recognized as the strongest player of his day.

In our issues of November 24th and December 1st we gave an account of the celebrated matches between De La Bourdonnais and Macdonnel, as well as of the last resting place of these renowned champions, it being remarkable that all of these distinguished French players, as well as Verdoni, Count Bruhl, and others, should have spent their last days in England.

De La Bourdonnais only died so recently as 1840, so we have met many players who have contested games with him, and the older habitués of the European chess cafés are quite familiar with his personal appearance, and tell many amusing anecdotes connected with his chess experiences.

Our portrait is taken from an oil painting made in London a short time before his death. It is not generally known that a plaster cast was taken from his features at the time of his death, and was brought to this country, and is at present in the possession of Mr. Eugene B. Cook, the distinguished problemist, who prizes it most highly, and takes peculiar pride in showing the stray locks of hair and whiskers that still adhere to the plaster.

It is difficult to compare the relative strength of the old and modern school of chess players; the recorded games of any player cannot be taken as a fair criterion by which to judge of his play, and the openings have undergone so many important changes that we can only judge by the brilliant *coups* or depth of combinations by which the player attains his end. In the field of problems the case is different; we can readily compare the ancient with the modern compositions, and find such a decided improvement that we feel inclined to believe that the entire science of the game has advanced, and that the modern player as well as the problemist has kept pace with the age of progress, and takes a clearer and deeper insight into the mysteries of the game than was dreamed of in the philosophy of our forefathers.

De La Bourdonnais made many problems, but like those of Philidor and other great players they generally have a semblance to positions from actual play. The following we give as a specimen of the old style of compositions:

ENIGMA No. 36.—BY LA BOURDONNAIS.

White.—K on K 6, R Q 5, B K R 7, Kt K B 5, Ps Q R 5 and Q 4.
Black.—K Q B 3, R Q B 8, Bs Q 3 and Q Kt 2, Kt Q B 6, Ps K 2, Q B 2 and Q Kt 4.
White to play and mate in four moves.

The following possesses more merit, however, and contains one of the modern tricks that even Mr. Pierce, the English critic, should have studied before launching his No. 143.

ENIGMA No. 37.—BY LA BOURDONNAIS.

White.—K on Q sq, Q K B 5, P Q B 7.
Black.—K K 2, R K 7, Ps Q 6, K 6 and K B 7.
White to play and win.

The death of La Bourdonnais was as sudden as it was premature. He was in the best of health and at the height of his fame, the recognized champion of the world. We give the following, which was the last game he ever played, being a game with Mr. Popert, one of the finest players in England, to whom La Bourdonnais gave the odds of pawn and move.

(Remove Black K B Pawn.)

MR. POPERT.	LA BOURDONNAIS.
WHITE.	BLACK.
1. P to K 4	1. Kt to K R 3
2. P to Q 4	2. Kt to K B 2
3. B to Q 3	3. P to K 3
4. Kt to K B 3	4. P to Q 4
5. P to K 5	5. P to Q B 4
6. P to Q B 3	6. Kt to Q B 3
7. Castles.	7. Q to Q Kt 3
8. P to Q R 4	8. B to Q 2
9. B to Q B 2	9. B to K 2
10. Q to Q 3	10. Castles Q R
11. P x P	11. Q to B 2
12. P to Q Kt 4	12. P to K Kt 4
13. Kt to Q R 3	13. Q Kt x Kt P
14. Kt x Kt	14. Kt x Kt
15. Q to K Kt 3	15. P to K R 4
16. P to K B 4	16. P to R 5
17. Q to K sq	17. Kt to K Kt 5
18. Kt to Q Kt 5	18. Q to Kt sq
19. P to K R 3	19. P to Q R 3
20. Kt to Q 4	20. P to K 4
21. P x Kt	21. Kt P x P
22. Kt to K B 5	22. Q R to K sq
23. P to Q B 4	23. P to K R 6
24. P x Q P	24. P x Kt P
25. K x P	25. P to B 6 ch
26. R x P	26. P to K 5
27. B x P	27. Q to R 7 ch
28. K to B sq	28. B x Q B P
29. P x B	29. Q to R 8 ch
30. K to K 2	30. R to R 7 ch
31. K to Q sq	31. R x B
32. Q x Q	32. R x Q ch
33. K to B 2	33. R x K Kt P

The game was interrupted at this point by the serious indisposition of La Bourdonnais, and was never resumed.

LOUIS CHARLES DE LA BOURDONNAIS.

THE AMERICAN CHESS CONGRESS OF 1871.

IN connection with the meeting of the Chess Congress that was held at Cleveland December 4, 1871, a prize of $15 was offered for the best set of three problems, and $10 for the second best, and $5 for the best single problem of the Tournament. The first prize, as well as the prize for the best problem of the Tournament, was awarded to T. M. Brown; second prize to Henry Northcote.

The only other set that was correct was by Jacob Elson, and received *honorable mention*. We select two of the winning problems.

DEATH OF MR. COCHRANE.

FROM the last issue of the *London Field* we learn of the death of this celebrated English player, who for more than half a century has been recognized as one of the strongest and most brilliant of chess players. We have no portrait of Mr. Cochrane, but it is most fitting that our tribute to his memory should appear in connection with our sketch of his old associate and friend, De La Bourdonnais. These two players were born very nearly at the same date, Cochrane, however, living to a good old age, and keeping up his love for the game after the lapse of fourscore years. As a brilliant player he has always been compared to La Bourdonnais, and the similarity of the style of their play has often been referred to.

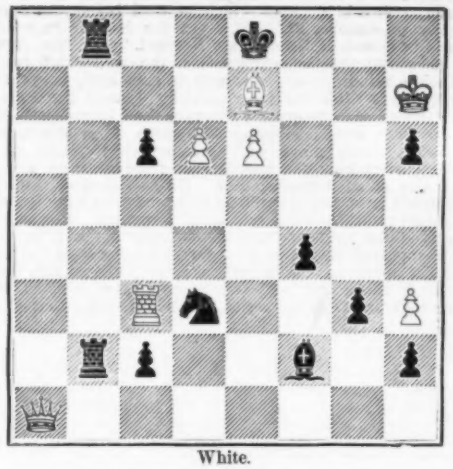
Mr. John Cochrane, who was about fourscore years old, was a descendant of an old Scotch family and a cousin of the famous Admiral, the late Lord Dundonald. Soon after having completed his education he entered the Royal Navy, and was a midshipman on board the Bellerophon at the time when that historical man-of-war carried Napoleon to St. Helena. After the conclusion of peace Mr. Cochrane quitted the service to qualify himself for the legal profession. In 1822 he was called to the bar of the Middle Temple, and soon afterward took up his residence in Calcutta, where he established himself in large practice as a barrister. In 1841 Mr. Cochrane paid a visit to this country, extending over two years, and he finally returned to England in 1870, where he stayed up to the time of his death.

As a chess player Mr. Cochrane made himself first known in Paris about the year 1821 by beating the celebrated French masters, Deschappelles and De La Bourdonnais, at the odds of pawn and two moves and pawn and move, in a short number of games. He afterward participated with those two great players in a series of twenty-three pools on even terms, of which De La Bourdonnais won nineteen, Deschappelles three, and Mr. Cochrane one. In 1822 Mr. Cochrane published a book on the game, which will always be regarded as marking an advance in the history of modern chess literature.

PROBLEM No. 69. BY HENRY NORTHCOTE.

Second Prize in the American Chess Congress of 1871.

Black.



White.

White to play and mate in four moves.

SOLUTIONS TO PROBLEMS.

No. 62.—BY J. BERGER.

WHITE.	BLACK.
1. B to Q B 6	1. K to Q 6
2. B x P ch	2. K to K 5
3. Kt to K 7 dis mate.	
	1. K to B 4
2. Q to K 8	2. Any move
3. B to Q 7 mate.	
	1. B x P
2. Kt x K P dis ch	2. K x Kt
3. Q to R 3 mate.	
	1. P queens
2. Kt x B P dis ch	2. K x Kt
3. Q to K B 8 mate (very difficult).	

No. 63.—BY J. BERGER.

WHITE.	BLACK.
1. R to B 8	1. Kt x Kt
2. Q to K Kt 6	2. K to B 4
3. Q x P ch	3. K x Q
4. R to Q B 8 mate.	
	1. B to B 6
2. P to K 3 ch	2. K to K 5
3. Kt to B 6 ch	3. P x Kt
4. Q x P mate.	

LETTER "B."—BY J. B. MUNOZ.

White to mate: 1.—P to K 6 ch, etc.
White to self-mate: 1.—B to R 5 ch, and Kt to K 6 ch.
Black to mate.—Kt to R 3 ch, etc.
Black to self-mate: 1.—Kt to R 3 ch, and Kt to K 3 ch.

ENIGMA No. 27.—BY HERR SCHRUEFER

WHITE.	BLACK.
1. Kt to Q R sq	1. P to B 4
2. B x P ch	2. Kt x B
3. Q to Kt 2 ch	3. K x Kt
4. Q to Q B 2 and mate.	

ENIGMA No. 28.—BY CONRAD BAYER.

WHITE.	BLACK.
1. Q to Q R 5	1. Any move
2. Mates.	

ENIGMA No. 29.—BY CONRAD BAYER.

The conditions must have been given to us incorrectly, as we see no shorter mate than the following:

WHITE.	BLACK.
1. Q to B sq	1. B x Kt
2. Kt to Q 3	2. P x Kt
3. P to B 4 ch	3. K moves
4. Q mates.	

ENIGMA No. 30.—BY CONRAD BAYER.

WHITE.	BLACK.
1. Q to B sq	1. Kt x Kt
2. R to Kt 5	2. Any move
3. Mates.	

ENIGMA No. 31.—BY ABELLA.

WHITE.	BLACK.
1. K to K 7	1. Any move
2. Mates accordingly.	

ENIGMA No. 32.—BY ABELLA.

WHITE.	BLACK.
1. Q to K B 5	1. P x Q
2. Kt to Q 4	2. Any move
3. Kt or B mates.	

ENIGMA No. 33.—BY ABELLA.

La Stratagie informs us that this problem should be in four moves, and a black pawn placed on K R 3.

WHITE.	BLACK.
1. Q to Q Kt sq	1. Q to K 8
2. B to B 2	2. R x B
3. Q to K R 7	3. Any move
4. Mates.	

ENIGMA No. 34.—BY P. T. DUFFY.

WHITE.	BLACK.
1. B to K 3	1. P to K 5
2. Q to R Kt 2	2. K x P dis ch
3. Q to Q 6 mate.	